Electricity Conservation and Acid Rain in Ontario

Prepared for the Ontario Ministry of Energy
by *Marbek Resource Consultants Ltd.*
and *Torrie, Smith & Associates.*

March, 1989

Ontario
Ministry of Energy

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Minister

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ELECTRICITY CONSERVATION AND ACID RAIN IN ONTARIO

Final Report

Prepared by:

Marbek Resource Consultants Ltd.
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Torrie, Smith & Associates

Prepared for:

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EXECUTIVE SUMMARY

This report describes a study commissioned by the Ontario Ministry of Energy with the following terms of reference:

- To update an earlier report done for the Ministry entitled Electricity Conservation Supply Curves for Ontario by extending the analysis of electricity conservation potential to the year 2000;
- To produce supply curves of peak capacity savings as well as for electricity savings; and
- To analyze the effectiveness and the comparative costs of electricity conservation as a means for reducing acid gas emissions in Ontario in the 1990's.

The method of analysis was developed through the collaborative efforts of staff of the Ontario Hydro, the Ministry of Environment and the Ministry of Energy. The study specifies measures and calculates the level of electricity conservation that would be necessary between now and the year 2000 to achieve specified reductions in acid gas emissions. While the conservation measures analyzed in the study are technically and economically feasible, the study did not attempt to analyze how the barriers to achieving these measures could be overcome or how likely the attainment of such conservation scenarios might be. Also, the measures included in the study were restricted to the measures that had been analyzed in the previous study -- Electricity Conservation Supply Curves for Ontario; no attempt was made to conduct a comprehensive assessment of the potential for electricity conservation in Ontario.

In developing the costs of the conservation measures (in cents per kilowatt-hour), the objective was to use a method that would allow direct comparison with the cost of electricity supply. The electricity savings potential and investment costs of the efficiency measures were taken directly from technical and engineering studies and converted to unit costs of saved electricity (in cents per kilowatt-hour) by amortizing the investments according to the same techniques and with the same discount rate used in costing new electricity supply options.

The costs of the conservation and efficiency measures analyzed are the total economic costs of the measures, not Ontario Hydro's costs. Unless specifically identified as retrofit measures, the technologies and efficiency measures were assumed to be taken up in new buildings and products at the normal rate of turnover due stock turnover and new demand.
Ontario Hydro's 1987 frozen efficiency forecast was used as a baseline for the year 2000 electricity demand, against which conservation and efficiency potential was measured. The

study found an energy savings potential of at least 33,000 GW.h (per year) by the year 2000, relative to the frozen efficiency forecast, all with measures with economic costs under five cents per kilowatt-hour. This is equivalent to about 25% of current annual production and 18% of Ontario Hydro's 1987 frozen efficiency forecast of demand for electricity in the year 2000.

Nearly half the identified savings potential is in commercial and institutional buildings sector (lighting systems, pumps, fans, motors) and about a third of the potential is in the residential sector (appliances, electric heated homes, electric water heat).

In terms of peak capacity, this electricity conservation potential translates into a potential to reduce the need for peak generating capacity in the year 2000 by 8,300 MW relative to the frozen efficiency forecast, or by about 22%.

The terms of reference of the study called for analysis of three conservation scenarios, sufficient to reduce Ontario Hydro's coal burn in the 1990's by an amount that would displace the need for two, four and six scrubbers, respectively. The identified conservation and efficiency potential was more than enough to meet the high conservation scenario (displace six scrubbers).

The economic costs of the scenarios were derived directly from the cost data used to develop the supply curves of electricity conservation. The economic benefits of the conservation investments were estimated using Ontario Hydro's incremental system values for power and energy. The analysis found that scrubbers appear to be a relatively economical option only when the narrow question of acid gas reduction is considered outside the broader context of power system planning and operation. In this broader context, where the objective is to both meet the demand for electricity and stay within the acid gas emission limits, conservation and efficiency produce a stream of economic benefits that more than offset the higher initial investment (as compared with scrubbers).

ACKNOWLEDGEMENTS

The efforts and cooperation of many individuals went into the research and production of this report. The principal researcher and author was Ralph Torrie of *Torrie, Smith and Associates*. Several of the senior staff at *Marbek Resource Consultants* contributed to the study, but a special acknowledgement is due to Martin Aube for his analytical contribution and computer graphics work.

Howard Geller of the *American Council for an Energy-Efficient Economy* in Washington, D.C. offered valuable advice and guidance based on similarly innovative projects in the U.S.

Personnel from both the System Planning Division and the Economics and Load Forecasting Division of Ontario Hydro gave generously of their time, information and advice, although we would hasten to add they bear no responsibility for the content or the conclusions of this report. Indeed, the approach to the subject of electricity supply and demand taken in this analysis is different from that of Ontario Hydro, and so their cooperation is all the more appreciated.

Finally, we are indebted to Dr. Larry Moore of the Ontario Ministry of Energy for his encouragement and support throughout this challenging and innovative exercise.

-- *Brian Kelly, President*
Marbek Resource Consultants Ltd.

TABLE OF CONTENTS

PART A. ELECTRICITY CONSERVATION POTENTIAL TO 2000

A.1 INTRODUCTION 1
A.2 THE ELECTRICITY DEMAND BASELINE FOR THE YEAR 2000 2
A.3 THE CONSERVATION DATA BASE 7
A.4 ELECTRICITY CONSERVATION POTENTIAL IN ONTARIO IN 2000 9
A.4.1 Residential Sector 9
A.4.1.1 Residential Sector Electricity Use in 2000 9
A.4.1.2 Residential Electricity Conservation Measures 10
A.4.1.3 Residential Sector Supply Curve 11
A.4.2 Commercial Sector 13
A.4.2.1 Commercial Sector Electricity Use in 2000 13
A.4.2.2 Commercial Sector Electricity Conservation Measures 14
A.4.2.2.1 Fluorescent Lighting Measures 14
A.4.2.2.2 Compact Fluorescent Substitutes for Incandescent Lighting 16
A.4.2.2.3 Motors Balancing 16
A.4.2.2.4 Energy Efficient Motors 17
A.4.2.2.5 Motor Scheduling 17
A.4.2.2.6 High Efficiency Cooling Equipment 17
A.4.2.2.7 Window Glazing 17
A.4.2.2.8 Water Heating Efficiency Improvements 18
A.4.2.2.9 Space Heating Conservation in New Buildings 18
A.4.2.3 Commercial Sector Supply Curve 18
A.4.3 Industrial Sector 21
A.4.3.1 Industrial Sector Electricity Use in 2000 21
A.4.3.2 Industrial Sector Electricity Conservation Measures 23
A.4.3.3 Industrial Sector Supply Curve 23
A.4.4 Composite Conservation Supply Curve 26
A.5 CONSERVATION OF PEAK POWER 28
A.5.1 Electricity Conservation and Peak Power Requirements 28
A.5.2 Supply Curve of Peak Demand Savings 29
A.5.3 Displaced Capacity 33
A.6 CONCLUSIONS 36

PART B. ELECTRICITY CONSERVATION AND ACID GAS EMISSIONS

B.1 ONTARIO HYDRO ACID GAS EMISSIONS 37

B.2 CONSERVATION AND ACID GAS EMISSIONS 38

B.3 SCENARIOS OF ELECTRICITY CONSERVATION 40

B.4 ECONOMIC ANALYSIS 44

B.5 CONCLUSIONS 50

BIBLIOGRAPHY

APPENDICES

APPENDIX I Statistical Tables, Frozen Efficiency Forecast Electricity Use in Ontario, Year 2000

APPENDIX II Database for Economic Analysis

APPENDIX III Excerpts from Electricity Conservation Supply Curves for Ontario, August 1987

APPENDIX IV Ontario Hydro Incremental System Values for Power and Energy, March 1989

ELECTRICITY CONSERVATION AND ACID RAIN IN ONTARIO

PART A. ELECTRICITY CONSERVATION POTENTIAL TO 2000

A.1 INTRODUCTION

This report describes a two-part analysis of the impact that demand management measures could have on Ontario Hydro's acid gas emissions in the 1990's. In Part A, we develop estimates of the potential for and costs of efficiency improvements and conservation in Ontario by the year 2000. These estimates are presented in the form of electricity conservation supply curves for Ontario for the year 2000, similar to conservation supply curves for 1985 developed in an earlier report entitled Electricity Conservation Supply Curves for Ontario[1]. Part B presents an analysis of the cost and effectiveness (as compared with scrubbers) of three scenarios for acid gas reductions based on electricity conservation measures.

Our objective in this part of the study is to estimate the potential for and the costs of electricity conservation and efficiency improvements in Ontario by the year 2000. These estimates are developed on a measure-by-measure basis, detailing costs and the total potential impact of each measure by the year 2000. The impacts of the measures are based on engineering information about the actual savings that can be achieved with the conservation technologies and measures. In order to allow a symmetrical comparison of these demand side measures with generation supply options, the costs of the conservation and efficiency technologies are annualized using the same techniques and rules used by Ontario Hydro to annualize the cost of new power plants. The results are then presented both as supply curves of electricity conservation (total potential expressed in GW.h) and as a composite supply curve of generation capacity (expressed in megawatts).

There are two basic requirements for conducting such a detailed analysis of the potential for conservation:

(1) a highly disaggregated model of the baseline electricity demand (i.e. pre-conservation) in the target year (the year 2000, in this case); and

(2) detailed information on the costs and energy savings of each of the conservation technologies or measures to be included the analysis.

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1. Marbek Resource Consultants, Electricity Conservation Supply Curves for Ontario, report prepared for the Ontario Ministry of Energy, August 1987. We have included excerpts from this report as Appendix III.

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(1) a highly disaggregated model of the baseline electricity demand (i.e. pre-conservation) in the target year (the year 2000, in this case); and

(2) detailed information on the costs and energy savings of each of the conservation technologies or measures to be included the analysis.

A.2 THE ELECTRICITY DEMAND BASELINE FOR THE YEAR 2000

A complete specification of electricity demand in the year 2000 requires numerous assumptions about Ontario's demography, economy, the level of demand for energy end use services, and electricity's market share and base efficiency level in each of the energy end use markets. The model of the baseline electricity use must be disaggregated by subsector and by end use to a sufficient level of detail to allow information about the individual conservation measures to be used to calculate total savings potentials. Thus, for example, in order to be able to measure the potential for energy savings from the use of more efficient refrigerators, the baseline energy model must specify the number of refrigerators in the base year and their average consumption, the energy consumption of the average new fridge in the base year, the replacement rate of old refrigerators between the base year and the target year, and the number of new refrigerators added to the stock between the base year and the target year. It is then fairly straightforward, if we know how much more an efficient refrigerator costs and how much less electricity it uses compared to the average levels in the energy baseline, to compute the total amount of electricity that could be saved if all new and replacement refrigerators were energy efficient models.

This analysis adopts Ontario Hydro's most likely forecast of economic growth and electricity demand (the Basic Forecast (1987)) as the basis for the analysis of the impact of conservation and efficiency improvements in future years. Where it was available and provided to us, we also have adopted Ontario Hydro's end use characterization of the Basic Forecast. However, Ontario Hydro's Basic Forecast does contain some of the conservation measures we wish to analyze, so we have used as our baseline of consumption in the year 2000 a special variation of the Basic Forecast called the Frozen Efficiency Forecast. In the Frozen Efficiency Forecast, the efficiency of electricity using technologies and processes is frozen at its base year level. That is, the base year stock remains at the same level of efficiency throughout the forecast period and all new stock in the forecast is assumed to have the same efficiency as new stock in the base year of the forecast. With respect to all the other factors that determine the demand for electricity, the Frozen Efficiency Forecast is identical to the Basic Forecast

(population, households, level and type of economic growth, demolition and stock disappearance rates, electricity's market share of energy end use markets, etc.).

We provide here only a summary of the Frozen Efficiency Forecast and how it is derived; some additional detail is provided as required in the sectoral conservation analyses below. A detailed description of Ontario Hydro's forecasting process and how it has evolved can be found in Ontario Hydro's annual load forecasts[1].

In summary, Ontario Hydro first produces a "business-as-usual" forecast, called the Basic Load Forecast, which is a projection of future electricity demand under the assumption that no special efforts are made by Ontario Hydro to encourage conservation, efficiency improvements, or load shifting. The Primary Load Forecast is then produced by estimating the electricity conservation and load shifting that will result from Ontario Hydro's planned incentive-driven demand management programs and subtracting that amount from the Basic Load Forecast.

To generate the Basic Load Forecast, Ontario Hydro modellers produce two separate forecasts of electricity demand, using two very different processes (an end use oriented, engineering-based, "bottom-up" technique, and an econometric, "top-down" technique). The "bottom-up" or End Use Forecast generally results in a lower forecast than the "top down" forecast (sometimes much lower) and to produce the official Basic Load Forecast, Hydro analysts use the range defined by these two forecasts and their experienced judgement to guess the final numbers.

Once a final set of numbers has been chosen, the End Use Model is "tuned" to those numbers. The difference between the End Use Forecast itself (the result of the "bottom-up" forecast referred to above) and the end-use "tuning" of the Basic Forecast is important to bear in mind. Whereas the End Use Forecast is the result of Ontario Hydro's best information and assumptions about the end use characterization of electricity use in Ontario and trends in the factors that affect it (eg. floor area of buildings, efficiency of technology, electricity market share, ownership rates of appliances, penetration of new electrotechnologies in industry, etc.), the tuned version of the Basic Forecast is simply an attempt to use the End Use Model to produce a plausible, physical description of future electricity use that corresponds to the totals in the Basic Load Forecast. The model must usually be tuned "up", as the Basic Load Forecast is generally higher than the End Use Forecast.

From the point of view of establishing a baseline for modelling specific conservation measures

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1. The analysis in this report is based on Load Forecasts Report No. 871214, System Demands, Economics and Forecasts Division, Ontario Hydro, May 1988. The most recent forecast is Load Forecasts Report No1. 881212, 1988 Long-Term Load Forecast, Economics and Forecasts Division, Ontario Hydro, December, 1988.

and efficiency improvements, the problem that arises is that there is already a significant amount of conservation reflected in the Basic Load Forecast, but it is not possible to specify it by measure or to rigorously calculate the total amount.

Ontario Hydro's response to this problem has been to introduce the concept of the "Frozen Efficiency Forecast". The Frozen Efficiency Forecast is produced by starting with the end use tuned version of the Basic Forecast, but with the efficiency of electricity use frozen at its base year level. This means the efficiency of the base year electricity using stock (eg. appliances, electric heated buildings, lighting systems, motors, etc. etc.) is frozen at its average level in the base year and all new electricity using devices that are introduced during the forecast period are assumed to have the same efficiency as typical new stock in the base year. Freezing efficiencies in the End Use Model this way after calibrating the model to the Basic Forecast has the effect of increasing forecast electricity demand in future years to a level significantly above the Basic Forecast. It is this higher "forecast" that is referred to as the Frozen Efficiency Forecast and the difference between the Frozen Efficiency Forecast (FEF) and the Basic Forecast can be considered one measure of the "natural conservation" (Ontario Hydro terminology) implicit in Ontario Hydro's Basic Forecast, where natural conservation refers to the conservation and electricity efficiency improvements that are forecast to occur without any special incentives from Ontario Hydro or government programs.[1]

Ontario Hydro's 1987 Basic Forecast and the corresponding Frozen Efficiency Forecast (FEF) are shown in Figure A.2.1. In the year 2000, total electricity demand in the FEF is 185.85 TW.h and the Basic Forecast totals 177.36 TW.h. The difference of 8.49 TW.h can then be considered an estimate of the "natural conservation" implicit in the 1987 Basic Load forecast. In other words, Ontario Hydro's Basic Forecast is about 8,500 GW.h (or about 5%) lower in the year 2000 than it would otherwise be if there were no conservation or efficiency improvements in the use of electricity between now and then.[2]

The Frozen Efficiency Forecast shows only the impact on electricity demand of freezing the efficiency of electrical technology; it does not reflect the impact of other facts that can be equally or more important in determining the demand for electricity -- market shares, end-

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1. This past year, Ontario Hydro has replaced the term "natural conservation" with the term "information-driven" conservation.

2. The analysis in this study is based on the 1987 forecast. A new forecast was issued in December, 1988 (the 1988 Load Forecast) in which the Basic Forecast for the year 2000 had been increased to 184.12 TW.h from 177.36 TW.h. The increase in the forecast is mostly due to the high actual demand in 1987 (which starts the 1988 forecast off from a higher base), and higher economic growth rates. A frozen efficiency analysis of the 1988 forecast has not yet been done (March 1989) but given that the increase in the forecast was not the result of any explicit assumptions about changes in the level of natural conservation, it is likely that a frozen efficiency version of the 1988 forecast would be higher than the 1987 FEF by about the same ratio as the Basic Forecasts and would yield a value for the year 2000 of about 192 TW.h.

use saturations and prices. In fact, in Ontario Hydro's most recent end use models of the Basic Load forecasts, assumptions about electricity's future share of the heating market have been much more important than technological efficiencies in explaining forecast growth in electricity demand. While the 1987 Frozen Efficiency Forecast is about five percent higher in the year 2000 than the Basic Forecast, freezing market shares at their base year levels would produce a forecast some 10-15% **lower** than the Basic Forecast.[1]

In our analysis of conservation potential, the Frozen Efficiency Forecast is used as the baseline of consumption in the year 2000. Ontario Hydro officials provided a detailed disaggregation of their end use model of the frozen efficiency forecast for the residential sector. For the commercial sector, they provided a similarly disaggregated description of the Basic Forecast and we had to construct a frozen efficiency scenario. For the industrial sector, we were provided with some helpful end use information about activity levels and electricity intensities. These descriptions formed the starting point for the sectoral analyses of conservation potential.

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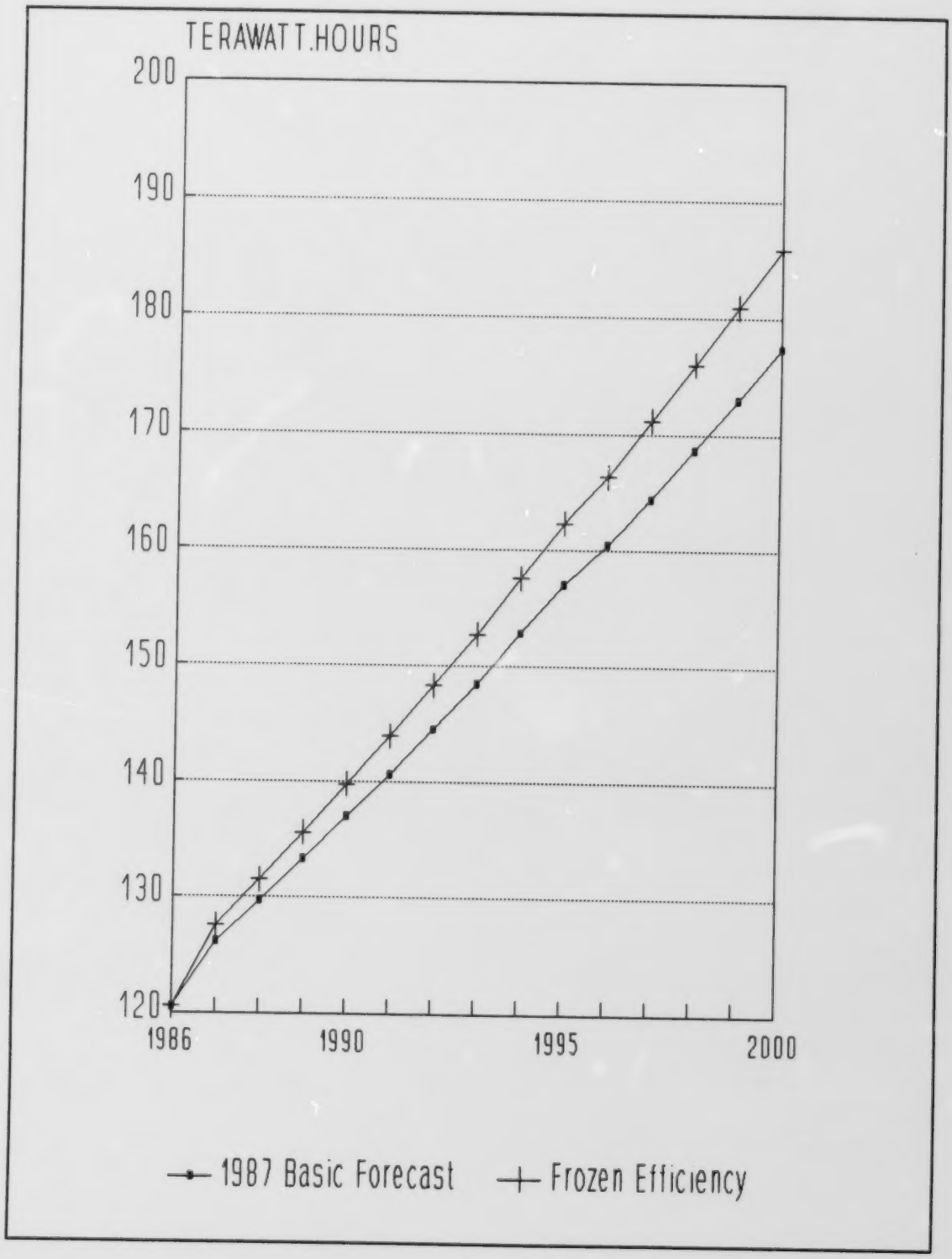
1. Market share assumptions and efficiency potential are interrelated, although it was beyond the scope of this study to analyze the impact on final demand and on conservation potential of different market share assumptions from those being adopted by Ontario Hydro. Suffice it note that the fact that assumed increases in electricity's market share of space heating are so much more important in raising the forecast than assumptions about efficiency levels are in lowering the forecast has important implications to the analysis of conservation and efficiency potential. The potential for much higher thermal efficiencies in new residential and commercial buildings (through better design, insulation, etc) is a potential for electricity conservation to the extent that these new buildings are electrically heated. Generally, the cost effectiveness of electricity as a heating fuel improves with the thermal efficiency of the building (although the specific electrical heating technology that is most appropriate will be different for buildings with different levels of the thermal efficiency). While much electricity can be saved by building new electrically heated buildings to the cost effective limit of thermal efficiency, much more is saved when the building is heated with some other fuel. To the extent Ontario Hydro is overestimating their future share of the space heating market our estimates of the potential for electricity conservation in these buildings will be high; on the other hand, in such a case, Ontario Hydro's Basic Forecast will be high to an even greater extent.

Fig. A.2.1 Basic Vs. Frozen Efficiency Forecast -- 1987



A.3 THE CONSERVATION DATA BASE

Once a highly disaggregated baseline description of electricity use has been created, estimates of the costs and effectiveness of various conservation and efficiency technologies can then be used to calculate the total potential for conservation and efficiency in the target year. The Call for Proposals that led to this work requested that the estimates of conservation costs and potential described in the report Electricity Conservation Supply Curves for Ontario be used as the basis for constructing electricity conservation estimates for the year 2000.

This was done, but a number of caveats and methodological issues related to using Electricity Conservation Supply Curves for Ontario as a basis for estimating the conservation potential for the year 2000 must be raised immediately.

-- First, Electricity Conservation Supply Curves for Ontario was produced as an attempt to test and illustrate the technique of conservation supply curves, and was not intended to present a comprehensive analysis of conservation and efficiency potential. It was only intended to include enough measures in the analysis to construct examples of what electricity conservation supply curves would look like for Ontario. Consequently, only a couple of dozen measures are analyzed in detail in Electricity Conservation Supply Curves for Ontario. While these measures include the technologies and efficiency improvements with the largest potential, there are many dozens of other measures not included in the analysis whose combined impact could be very significant. Further, the conservation estimates in Electricity Conservation Supply Curves for Ontario were based on readily available information (much of it from Ontario Hydro studies); there was no attempt to conduct a comprehensive review of the state-of-the-art of electricity efficiency and conservation technologies.

-- Second, Electricity Conservation Supply Curves for Ontario contains no analysis of the costs and effectiveness of conservation and efficiency improvements that can be made with respect to new activities and new buildings. To estimate the potential for electricity conservation in 2000, it is clearly necessary to include the potential for conservation associated with all the new electricity using activity and processes and buildings that result from economic growth between now and the year 2000. Both the cost and effectiveness of a particular conservation measure will be different for new activity than for retrofits. Generally, the costs will be lower and the effectiveness will be higher (it is cheaper and easier to design improvements in from the outset than to add them on later).

-- Third, in Electricity Conservation Supply Curves for Ontario, the total potential of a particular conservation measure was calculated as the product of the potential of a single application of the measure and the number of possible applications. For example, the potential contribution from energy efficient refrigerators was calculated by multiplying the number of refrigerators in the province in 1985 by the kilowatt.hours per year that could be saved by replacing a single (average) fridge with the energy efficient model. This is the correct method for measuring the total absolute potential for conservation, but in this study we are interested in the total potential that can be realized by a certain date, the year 2000. Therefore, estimates of conservation potential in the base year stock in this study have been calculated using current stock turnover rates.[1]

-- For this study, 1989 was chosen as the base year. The activity levels shown for 1989 in Ontario Hydro's end use model of the Basic Forecast (i.e. housing, commercial building floor area, appliance populations, industrial infrastructure, etc.) were taken as the base stock and activity levels. Estimates of the potential for electricity conservation and efficiency in new stock were assumed to apply from 1990 forward, and retrofit estimates were assumed to apply to all stock up to and including 1989. This required that the estimates in Electricity Conservation Supply Curves for Ontario, which were for 1985, had to be revised to take into account the new base year.

-- The costs of electrcity conservation and efficiency improvements in Electricity Conservation Supply Curves for Ontario and also in this report are **total** costs, not just the portion borne by Ontario Hydro or by the end users. For this reason they will generally be greater than the direct costs Ontario Hydro will typically associate with achieving a given level of conservation. In contrast to electricity supply projects, Ontario Hydro will generally not assume the full cost of demand management measures for meeting end use needs.

-- Finally, a number of constructive criticisms and comments were received with respect to Electricity Conservation Supply Curves for Ontario and these have been incorporated in this updated analysis.[2]

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1. There is a significant conservatism embedded in this technique. In this analysis we have based the estimate of total conservation potential on the amount of conservation that could be realized if efficient technologies were used to replace existing technologies at their natural replacement rate. The potential that could be realized by 2000 would be significantly higher if we included an analysis of early retirement of energy inefficient technology. Programs, such as that being tried by B.C. Hydro, in which a "bounty" is offered for old and inefficient refrigerators, are an example of how such an early retirement potential could be realized.

2. We are particularly indebted to the Mr. Gary Schneider of Ontario Hydro and Dr. John Robinson of the University of Waterloo for their detailed and useful comments on Electricity Conservation Supply Curves for Ontario.

A.4 ELECTRICITY CONSERVATION POTENTIAL IN ONTARIO IN 2000

A.4.1 Residential Sector

A.4.1.1 Residential Sector Electricity Use in 2000

A profile of baseline electricity use in the residential sector was constructed on the basis of information provided by Ontario Hydro describing the End-Use Model frozen efficiency simulation of the 1987 Basic Forecast. A summary of this profile is shown in Table A.4.1.1; some additional details on the space heating and electricity-specific end uses are included in Tables I.1 and I.2 in Appendix I.

In the Frozen Efficiency Forecast, total residential electricity consumption in 2000 reaches 55,440 GW.h, about 4.7% higher than in the Primary Forecast, indicating natural conservation gains of about 2,500 GW.h by the year 2000[1]. Electricity growth in the residential sector outstrips household formation in both the Primary and Frozen Efficiency Forecasts. Natural conservation gains are small compared to increased electricity demand due to an assumed greater market share for electric heating and strong growth in electricity-specific end uses. The latter is dominated by assumed growth in the use of electricity as an auxiliary heating fuel and by high growth rates in the unspecified "other" category of household electricity use (see Tables I.1. and I.2 in Appendix I).

With respect to the potential for conservation in the space heating application, we have maintained the assumption that the base stock of single family detached dwellings in 1990 have space heating requirements in the range of 19,500 - 23,500 kW.h, the values used by Ontario Hydro in the 1987 Frozen Efficiency Forecast. Water heating market share declines although the impact on total forecast electricity demand is small, as is the impact of strong growth in air conditioning.

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1. This amount of natural conservation is relatively small compared to the level of "uncertainty" in the forecast from other factors. In the 1988 Basic Forecast, changes in assumptions about residential construction growth, electricity market shares and penetration rates resulted in an increase in the forecast residential electricity demand in the year 2000 by an amount greater than the total natural conservation embedded in the 1987 forecast.

TABLE A.4.1.1

SUMMARY OF RESIDENTIAL ELECTRICITY USE
ONTARIO HYDRO FROZEN EFFICIENCY FORECAST (1987)
ALL HOUSEHOLD TYPES (DETACHED, ATTACHED, APTS)

	1985	1989	2000
TOTAL DEMAND (TW.h)	35.6	41.2	55.5
NO. OF HOUSEHOLDS (000's)	3270	3591	4382
AVERAGE HOUSEHOLD DEMAND (kW.h)	10,880	11,470	12,660
SPACE HEATING			
Market Share (%)	17.9	22.0	27.4
Average Demand per Electric Heated Household (kW.h)	13,380	13,650	13,500
TOTAL DEMAND (TW.h)	8.3	11.7	17.2
WATER HEATING			
Market Share (%)	44.3	39.2	35.1
Per Household Demand (kW.h)	5000	5000	4800
TOTAL DEMAND (TW.h)	7.2	6.9	7.4
APPLIANCES			
Per household demand (kW.h)	5,953	6,082	6,712
TOTAL DEMAND (TW.h)	19.5	21.8	29.4
COOLING			
TOTAL DEMAND (TW.h)	0.6	0.8	1.5

A.4.1.2 Residential Electricity Conservation Measures

The objective of this study is to base estimates of the potential for electricity conservation in 2000 on the conservation and efficiency measures included in Electricity Conservation Supply Curves for Ontario. In that study, a number of thermal retrofit measures (for electric-heated houses) were considered in addition to the potential savings that could be achieved through

the use of energy efficient home appliances. For the thermal retrofit measures, we have extended the definition of new houses to include all houses built up to and including 1990[1] (as per the 1987 forecast) and have recalculated the thermal retrofit potential on this basis, allowing for two vintages of "existing" housing (pre-1981 and 1981-1990). For new electric heated housing (1991-2000), estimates have been included of the cost and potential of higher degrees of energy efficiency than reflected the Frozen Efficiency Forecast (or the Primary Forecast), using Ontario Hydro's assumptions about growth in electricity's share of the space heating market. For purposes of defining the total potential for conservation through the use of energy efficient appliances, we have based the calculations on estimates of the new and replacement market between 1990 and 2000, with no allowance for accelerated replacement rates.

A.4.1.3 Residential Sector Supply Curve

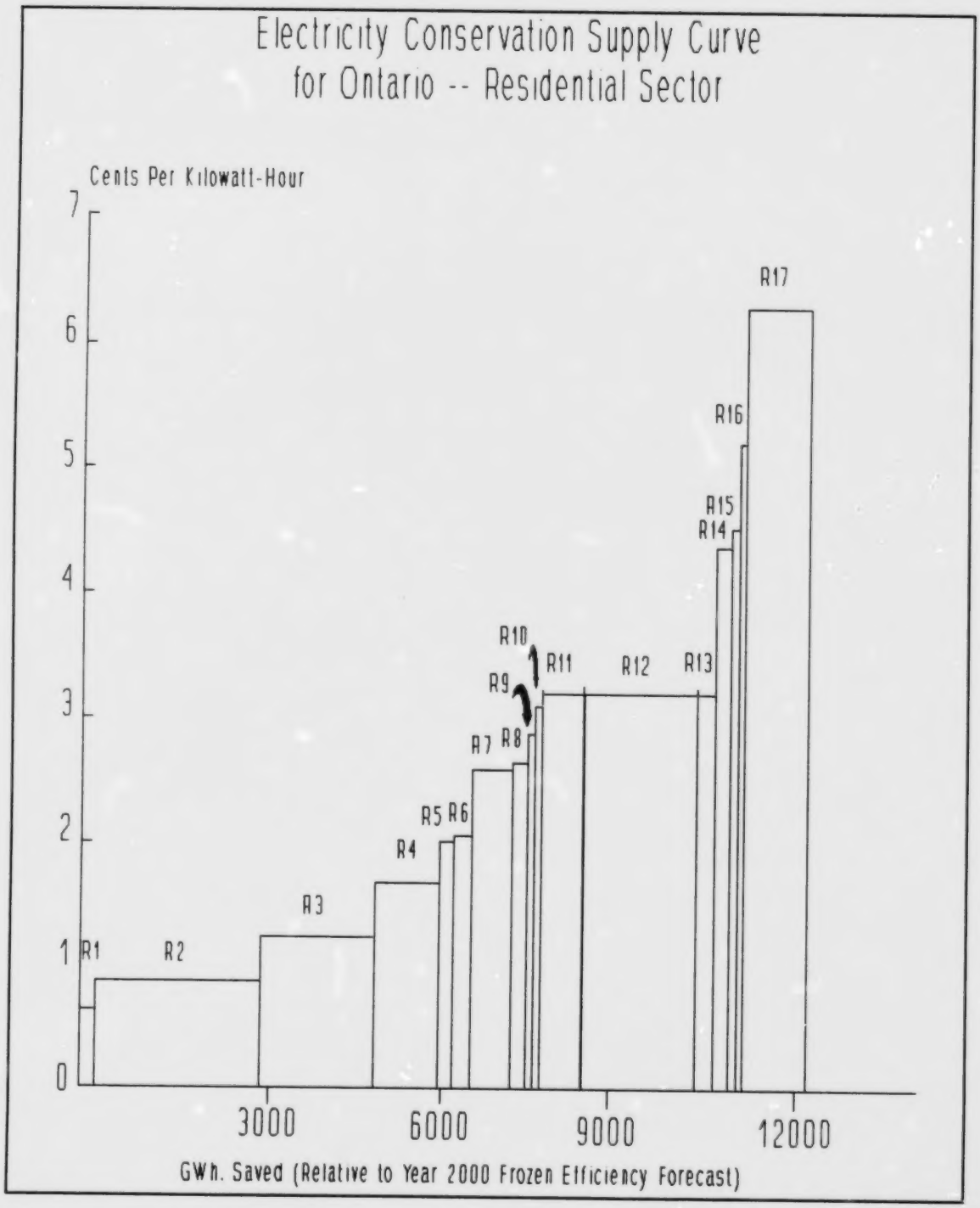
The conservation measures were applied to the baseline residential electricity consumption to yield the conservation supply blocks in Table A.4.1.2 and shown on the residential electricity conservation supply curve in Figure A.4.1.1.

TABLE A.4.1.2
ELECTRICITY CONSERVATION SUPPLY CURVE FOR ONTARIO
-- RESIDENTIAL SECTOR --

	MEASURE	SAVINGS GW.h)	WEIGHTED UNIT COST (cents/KW.h)
R1	Thermal Retrofit - Pre 81 Apts	202	0.59
R2	Water Heating	2700	0.80
R3	Efficient Refrigerators	1950	1.13
R4	Pre-81 SFD Insulation	1094	1.63
R5	1981-90 SFD - Infiltration	258	1.97
R6	1991-2000 Apts - Thermal Upgrade	204	2.00
R7	Efficient Freezers	750	2.50
R8	Pre 81 SFA - Thermal Retrofit	276	2.54
R9	Pre-81 SFD Windows	146	2.80
R10	1981-90 SFA Retrofit	43	3.03
R11	Pre-1981 SFD Insulation	704	3.19
R12	1991-2000 SFD Thermal Upgrade	2141	3.23
R13	1991-2000 SFA Thermal Upgrade	104	3.23
R14	Pre-1981 SFD Door Retrofit	292	4.28
R15	1981-90 SFD Insulation	91	4.44
R16	1981-90 SFD Door Upgrades	69	5.16
R17	Compact Fluorescent Substitution	1068	6.20
	TOTAL	**12093**	

1. This differs from the commercial sector, in which buildings added to the stock starting in 1990 are treated as "new". In the residential sector, houses added to the stock from 1991 onward are treated as "new".

FIGURE A.4.1.1


Electricity Conservation Supply Curve
for Ontario -- Residential Sector
Cents Per Kilowatt-Hour
7
6
5
4
3
2
1
0
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
R16
R17
3000
6000
9000
12000
GWh. Saved (Relative to Year 2000 Frozen Efficiency Forecast)

A.4.2 Commercial Sector

A.4.2.1 Commercial Sector Electricity Use in 2000

For the commercial sector, Ontario Hydro provided a detailed specification of the tuned version of the Basic Forecast, but not for the Frozen Efficiency Forecast. For the FEF, we were provided only with the commercial sector total electricity use by year over the forecast period. Building-related commercial electricity use is forecast to increase from 34.5 TW.h in 1986 to 56.8 TW.h in the FEF and to 54.0 TW.h in the Basic Forecast, reflecting a total of about 2.8 TW.h of natural conservation.

The strong forecast growth in electricity use in this sector is reflected in the end use model of the forecast by increasing market shares for electric heat (including very strong growth in heat pumps) and increasing intensity of electricity-specific applications. Compared to these trends, the 2,800 GW.h of natural conservation is a relatively minor factor in the forecast demand in 2000. The Frozen Efficiency forecast is about five percent higher than the Basic Forecast by the year 2000, but analogous calculations to produce a "frozen market share" forecast would yield a forecast demand in the year 2000 some 15-20% below the Basic Forecast.

Our first task in this sector was to create a detailed specification of electricity use in the sector in 2000, by building type and end use, and calibrate it to the total electricity use for the sector under Ontario Hydro's Frozen Efficiency Forecast.

Floor area by vintage by building type from Ontario Hydro's end-use tuned version of the Basic Forecast was combined with electricity intensities and market share estimates based on Hydro and other sources. The data base in Electricity Conservation Supply Curves for Ontario had more detailed subsector disaggregation than Ontario Hydro's end use model, so the floor area projections in Ontario Hydro's base forecast were further disaggregated (eg. the sum of the floor areas for Elementary School, Secondary School, Colleges, and Universities equals Hydro's total for Education Buildings, and the weighted average electricity intensity for these four subsectors equals Hydro's electricity intensity for Education Buildings).

To facilitate separate analysis of the costs of conservation measures on new vs. old buildings, the profile includes two vintages: pre-1990 stock and 1990-2000 stock. The pre-1990 stock in 2000 consists of the surviving 1980 vintage stock (from Ontario Hydro's end use model) plus the 1981-1989 stock.

The stock average energy intensities used for the 1985 baseline in Electricity Conservation Supply Curves for Ontario were adopted as stock average intensities for the 1989 stock in the updated curves. For new stock (1990-2000), energy intensities were frozen at the efficiency

levels corresponding to new stock in 1989, which were in turn derived from the tuned version of the Basic Forecast.

The resulting calibration of the commercial buildings sector is summarized in Tables I.3, I.4 and I.5 in Appendix I to the pre-1990, 1990-2000 and total stock, respectively. Total building-related electricity use in 2000 in this calibration is 52.2 TW.h. This compares with the frozen efficiency forecast total commercial sector electricity use of 56.2 TW.h, which includes about 4 TW.h of non-building related electricity use (mostly street lights and municipal water works). The specification on of the commercial buildings sector detailed in Tables I.3, I.4 and I.5 formed the baseline for our estimates of the potential for conservation and efficiency improvements in this sector.

A.4.2.2 Commercial Sector Electricity Conservation Measures

In Electricity Conservation Supply Curves for Ontario, 105 "blocks" of conservation potential were included in the supply curve for the commercial sector by combining information on the costs and energy savings of ten conservation/efficiency improvement measures with a profile of actual 1985 Ontario commercial sector electricity use, disaggregated by 16 building types (plus a residual) and six end uses. In this study, the same measures are analyzed with respect to the impact they could have on the year 2000 electricity consumption as specified in the Frozen Efficiency Forecast (Tables I.1 through I.3).

This means adjusting the total potential to the 1989 floor area estimates and also to reflect assumed stock turnover rates, where relevant. In addition, in extending the curves to the year 2000, it was necessary to include estimates of the costs of the measures when applied to new buildings at the design and construction stage, to estimate the potential savings of the measures in new buildings relative to the new building practice assumed in the baseline for 1989, and to estimate the incremental cost and effectiveness of space heating conservation measures in new electrically heated buildings.

The following summarizes, on a measure-by-measure basis, the method and assumptions used in estimating commercial sector electricity conservation potential in the year 2000.

A.4.2.2.1 Fluorescent Lighting Measures

In Electricity Conservation Supply Curves for Ontario, the basic unit for analysis of energy conservation in fluorescent lighting is the four-foot two-40W lamp luminaire. Three levels of technological efficiency improvement were analyzed. The Level One measures consist of replacing 40 W lamps with first generation energy efficient lamps (drawing 34 W) and the ballasts with first generation efficient core ballasts (drawing 10 W instead of the conventional

16W). Combined with the ballast savings due to the lower wattage lamps, the total savings are about 25% of the baseline technology. The lighting level is reduced 7%-12%. A $10 premium and 20 year lifetime are assumed for the ballast and a $1.50 premium (75 cents each) and five year lifetime for the lamps [MARBEK 1986]. The resulting annualized cost of $1.07 per fixture is then applied to the particular conditions for each building type to determine overall potential and cost by building type.

The Level Two measures for fluorescent lighting include adding a silver film optical reflector to the luminaire, which allows half of the lamps to be eliminated. The remaining lamps are replaced with high performance 40W lamps to ensure lighting levels are maintained. The premium for the lamps is assumed to be equal to the savings from lamp elimination (premium for high performance lamps can be as high as $2/lamp). The reflectors are assumed to have a $50 cost [MARBEK 1986] and a twenty year lifetime. The electricity savings from the reflectors result from the lamp elimination. Compared to the baseline energy use, the reflector and the high performance lamps would deliver the same lighting level with about 50% of the electricity (assuming efficient core ballasts are included). When implemented subsequent to the Level One measures, the installation of the reflectors and high performance lamps cut electricity use by about 32%, although this could be increased to 50% if the low wattage lamps (and consequent lower light levels) were maintained.

The Level Three measures for fluorescent lighting include installation of electronic, dimmable ballasts with photocell controls, reflectors and high performance 40W lamps. It is assumed that the electronic ballast and photocell controls would be installed at the same time as the reflector. A total cost of $115 per luminaire is assumed for the ballast and reflector (installed), or a $65 premium for the ballast [MARBEK 1986]. The photocell controllers are assumed to cost $200 each, installed [RMI 1986, LBL 1985]. Each photocell controller controls the light output of four to eight luminaires, depending on the building type and size. The combination of the dimmable ballast and the photocell controller allows electricity savings from compensation for lumen depreciation over the life of the lamp and daylighting, which depends on the perimeter/core ratio and window area. Total electricity savings relative to the baseline with this package of measures can be as high as 85%.

In this analysis, for each building type and vintage, lighting conservation was analyzed at the level that would yield the highest energy savings for a unit cost of less than five cents per kilowatt-hour of saved electricity. In practice this means only Level Two and Level Three lighting conservation measures were analyzed for new buildings. In the Frozen Efficiency Forecast, new buildings (post-1989) already have measures incorporated which are roughly equivalent to Level One measures.

The impact of these measures on heating and cooling electricity requirements affect the total savings and unit cost of lighting electricity conservation measures. These impacts will depend on the type and size of building and are particularly sensitive to the presence or absence of an economizer in the building cooling system [EIL 1986]. The following assumptions were used in computing the cooling and heating (electric heated buildings only) impacts of lighting conservation measures, based on the EIL analysis for small and large office and retail buildings [EIL 1986]:

	For each kW.h reduction in internal load	
Building Type	Heating Energy increase (kW.h)	Cooling Energy decrease (kW.h)
Small Office	0.32	0.10
Large Office	0.24	0.13
Small Retail	0.31	0.15
Large Retail	0.31	0.15
All Others	0.30	0.10

A.4.2.2.2 Compact Fluorescent Substitutes for Incandescent Lighting

Incandescent light bulbs can be replaced with compact fluorescent light bulbs that use a fraction of the electricity to provide the same amount of light. The compact fluorescent bulbs are assumed to have a 10,000 hour lifetime and cost $22 each. Because of the high initial price, the cost effectiveness of these bulbs depends on the hours of usage for any particular application (which determines the amortization period applied to the investment). They will tend to be most cost effective in situations with high usage rates (eg. commercial building stairwells, exit lights and 24-hour per day applications in hotels, etc.).

A.4.2.2.3 Motors Balancing

Significant electricity savings can be achieved through the proper air and water balancing of fan and pump motors in HVAC systems of commercial buildings. In Electricity Conservation

Supply Curves for Ontario, the cost and savings figures from [EIL 1986] were used to compute fan and pump motor electricity savings due to air and water balancing, respectively. The savings per unit floor area were multiplied by total floor area by building type to estimate total savings from these measures.

A.4.2.2.4 Energy Efficient Motors

Cost premiums and savings for the replacement of electric motors by energy efficient motors are taken from the Engineering Interface analysis [EIL 1986]. This measure has a very small unit cost of saved electricity, based on the premium cost of the EE motors. This potential is based on all motors in new buildings and on the replacement rate of motors in old buildings.

A.4.2.2.5 Motor Scheduling

Costs per unit floor area and electricity savings for motor scheduling are taken from [EIL 1986]. Investments are amortized over ten years and the total savings are calculated using the building type floor areas from Tables A.4.2.1 and A.4.2.2.

A.4.2.2.6 High Efficiency Cooling Equipment

The cost effectiveness and impact of conservation measures for cooling equipment are highly variable from one building to the next and also depend on the internal load reductions achieved by other conservation measures that reduce the internal heat gain in the building. In its technology review, Engineering Interface [EIL 1987] suggest an energy efficient chiller will save 18% compared to the standard selection chiller, with the 10% premium cost having an average payback of the order of 5 years or less (equivalent with our costing method to about two cents per kilowatt-hour). In the case of high efficiency unitary cooling equipment, premiums of 10 to 15% are typical, with savings averaging 12% and paybacks two to three years. We have assumed that 18% and 12% savings can be achieved for 2 ¢/kW.h (premium) with high efficiency central and unitary equipment, respectively.

A.4.2.2.7 Window Glazing

For electric space heated buildings, the only conservation retrofit measure included in Electricity Conservation Supply Curves for Ontario is window glazing. Using a cost of $3/ft^2, of window area and a lifetime of 10 years, we have assumed the application of such glazing could reduce space heating requirements by 20% [EIL 86]. Total window area is estimated from the EIL "typical building" analysis.

A.4.2.2.8 Water Heating Efficiency Improvements

In Electricity Conservation Supply Curves for Ontario, an overall savings of 20% in water heating energy requirements is assumed to be available at a cost of 2 cents per kilowatt-hour or less, based on the costs of measures such as improved heater efficiency, upgrading of tank and pipe insulation, temperature reduction, and scheduling of the recirculation pumps during periods of low demand.

A.4.2.2.9 Space Heating Conservation in New Buildings

In the frozen efficiency forecast, electricity's share of the space heating market increases but the levels of energy efficiency assumed for new buildings are very modest compared to the technical and economic potential. By virtue of their size, the energy efficiency of commercial and institutional buildings is determined as much by the overall energy balance design and control systems as by the integrity and thermal resistance of the building shell. It is also generally true that just as the cost of energy is a relatively small component of most commercial and institutional operations, the premium cost of designing and building new structures to high levels of energy efficiency is very small. In fact, the costs of energy efficient commercial buildings do not show a significant correlation with energy demand levels [EMR 1980, SRC 1987] and surveys and studies from several countries show that for new commercial buildings, compared to standard practice, there is a cost-effective potential for more than a 75% reduction in energy intensity using improved designs with no net increase in capital cost [Armstrong 1984, Goldemberg 1985a]. We have assumed that 40% savings could be achieved relative to the frozen efficiency baseline, at a cost of saved electricity of 0.5 ¢/kW.h.

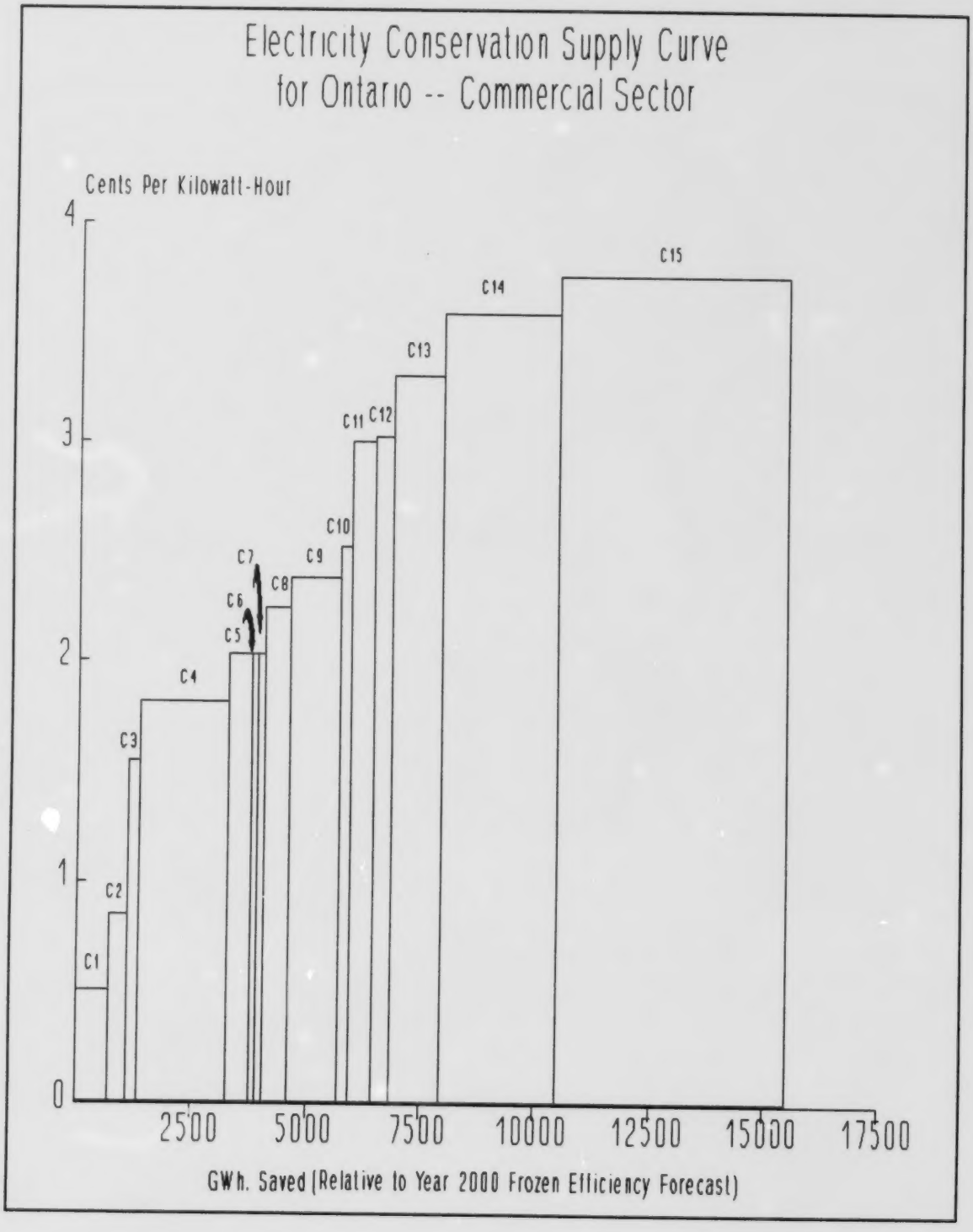
A.4.2.3 Commercial Sector Supply Curve

The conservation measures described above were applied to each the building types and vintages, resulting in 152 blocks of conservation supply for the commercial sector. To facilitate their presentation, the blocks were consolidated by adding the total potential and calculating a weighted average unit cost for each measure. The resulting consolidated conservation blocks, listed in Table A.4.2.1, form the components of the commercial sector conservation supply curve, shown in Figure A.4.2.1.

TABLE A.4.2.1
ELECTRICITY CONSERVATION SUPPLY CURVE FOR ONTARIO
-- COMMERCIAL SECTOR --

MEASURE		SAVINGS (GW.h)	WEIGHTED UNIT COST (cents/KW.h)
C1	Space Heating (new stock)	749	0.50
C2	Energy Efficient Motors	392	0.84
C3	Window Glazing	229	1.51
C4	Motor Balancing	1977	1.79
C5	Motors -- General	537	2.00
C6	Water Heating	172	2.00
C7	Cooling -- "other"	70	2.00
C8	High Efficiency Cooling Equipment	570	2.21
C9	Motor Scheduling	1144	2.38
C10	Space Heating (old stock)	222	2.50
C11	Compact Fluorescents	553	2.98
C12	Lighting -- General	399	3.00
C13	Level II Lighting	1131	3.27
C14	Level III Lighting (new stock)	2566	3.52
C15	Level III Lighting (old stock)	5164	3.73
	TOTAL	**15875**	

FIGURE A.4.2.1


Electricity Conservation Supply Curve
for Ontario -- Commercial Sector
Cents Per Kilowatt-Hour
4
3
2
1
0
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
C12
C13
C14
C15
2500
5000
7500
10000
12500
15000
17500
GWh. Saved (Relative to Year 2000 Frozen Efficiency Forecast)

A.4.3 Industrial Sector

A.4.3.1 Industrial Sector Electricity Use in 2000

In the end use model used by Ontario Hydro for the industrial sector, 14 subsectors are defined[1], and each industrial subsector consists of a number of specific processes. Each process can in turn be provided a number of different technologies. Total fuel and electricity demands are modelled by combining the energy intensities and market shares of the technologies with the activity levels for the various processes, which are in turn driven by exogenous, econometric forecasts of industry outputs. In the Frozen Efficiency Forecast, the energy efficiency of industrial processes (energy per unit of output) is held constant, and so is the relative penetration of energy efficiency technologies (eg. electrotechnologies).

Forecast electricity demand increases from a 1986 base of 44.5 TW.h to 65.2 TW.h in the Basic Forecast (1987) and 68.4 TW.h in the Frozen Efficiency Forecast. As in the residential and commercial sectors, the level of natural conservation accumulated by the year 2000 -- 3.21 TW.h -- is small compared to the growth in forecast demand of more than 20 TW.h.

Most electricity use in the industrial sector is for motive drive, with lighting, electricity-specific processes (eg.electrochemistry) and some specialized process heat end uses comprising the remainder. Motive drive and lighting end uses can be expected to remain fairly stable (although conservation potential is great for both applications); similarly, the potential for efficiency gains in traditional electricity-specific process technologies can be described with some precision. It is difficult, however, to determine the potential impact on electricity demand of changes in the mix of industrial output and in changes in production technologies. In applications where electrotechnologies displace fossil fuel use, there is very often a fundamental change in the production process, usually accompanied by a decline in the overall energy intensity of production and smaller increase in the electricity intensity of production. In any event, the diffusion of electrotechnologies will not have a very large impact on the aggregate demand for electricity by the year 2000. Industrial electricity use will continue to be dominated by motive drive, the intensity of which varies by industry, and the overall electricity intensity of industrial production is expected to continue to decline throughout the 1990's as it did in the 1980's.

A review of input/output data for Ontario industry indicates that there is a fair correlation between electricity intensity and major electrical users; exceptions include Petroleum and Coal Products (intensive but not a big user) and Transportation Equipment (non-intensive but a big

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1. Abrasives, agriculture, automobiles, cement, clay, food and beverage, glass, industrial chemicals, iron foundries, iron and steel, lime, mining and smelting, pulp and paper and "other" manufacturing.

user). To improve on the industrial analysis in Electricity Conservation Supply Curves for Ontario, we have therefore broken out industry into five subsectors -- primary metals (including mining and smelting), chemicals, pulp and paper, food and beverage, and other manufacturing. (The food and beverage industry is included because of its use of electricity for refrigeration.)

The table below details the distribution of electricity use among electricity-specific applications (motors, lighting, electrolysis and refrigeration) in these industries; the residual shares were applied to the aggregate industrial total and were used as the basis for estimating the potential for saving electricity through general heat recovery and process control measures.

DISTRIBUTION OF ELECTRICITY USE BY END USE (%)

End-Use	Metal	P&P	Chem	F&B	OTHER
Motors	26	95	13	40	81
Lighting	6	5	7	13	9
Electrolysis	53	--	60	--	--
Refrigeration	--	--	--	40	--

The distribution of electricity use in this table is based on the distribution in Electricity Conservation Supply Curves for Ontario, with additional information from recent reports [Hydro 1986c, Sharpe 1987, EPRI 1985, Marbek 1988]. The most significant change in this breakdown as compared with Electricity Conservation Supply Curves for Ontario is the inclusion of electrolysis. This end use appears to be lumped in with motor use in Ontario Hydro's industrial electricity use characterization, but in view of the importance of the chlor-alkali industry in Ontario, electrolysis efficiency improvement presents a significant potential for efficiency improvement that needs to be analyzed separately. We have also assumed that all industrial refrigeration takes place in the food and beverage industries. One conclusion of this revised estimate of the distribution of industrial electricity use in Ontario is that motors constitute a somewhat smaller share of total industrial electricity use in Ontario than has been usually assumed (ie. about 64%, not 75%).

A.4.3.2 Industrial Sector Electricity Conservation Measures

In Electricity Conservation Supply Curves for Ontario, six measures for industrial electricity conservation potential were analyzed -- waste heat recovery, process controls and instrumentation, energy efficient lighting, energy efficient refrigeration, energy efficient motors, and variable speed drives. In this analysis we have included all these measures plus one additional one -- advanced, energy efficient electrolysis processes.

The changes to the estimates in Electricity Conservation Supply Curves for Ontario are marginal, and relate mostly to updating the potential to 2000, with a few exceptions. We have reduced our estimate of the potential for efficiency improvements in industrial lighting systems from 50% to 25% in response to criticisms that the estimates in Electricity Conservation Supply Curves for Ontario do not allow for the fact that industrial lighting is already more energy efficient than in other sectors. On the other hand, the estimates in Electricity Conservation Supply Curves for Ontario of the conservation potential from the application of variable speed drives in industry appear to be too low.

For electrolysis, we have assumed 6% savings can be achieved through retrofit (no radically new cell designs), but that a much larger savings potential will be realized as the oxygen-air electrodes penetrate the market during the 1990's. There is a dearth of available information on the costs of the improved cell technologies, but cost effectiveness can be assumed based on the improved efficiency and the speed at which industry analysts expect the new cells to take over the market. We have assumed these savings (retrofit and improved cell designs) provide saved electricity in the range of 3.5-4 ¢/kW.h.

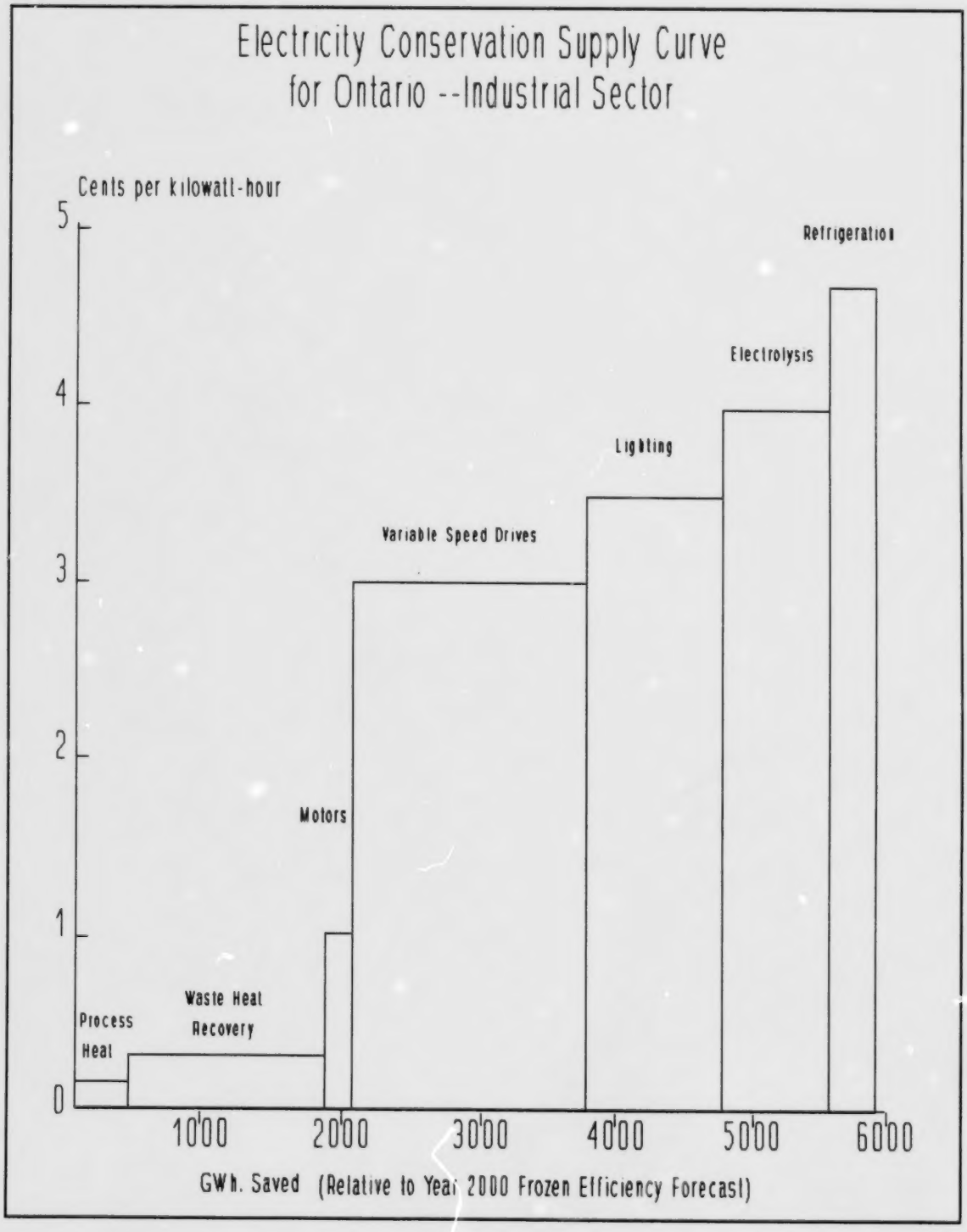
A.4.3.3 Industrial Sector Supply Curve

The conservation measures discussed above were applied to the forecast electricity demands in 2000 for the analyzed subsectors to yield the conservation blocks for the industrial sector supply curve shown in Table A.4.3.1 and illustrated in Figure A.4.3.1.

TABLE A.4.3.1
ELECTRICITY CONSERVATION SUPPLY CURVE FOR ONTARIO
-- INDUSTRIAL SECTOR --

MEASURE	SAVINGS (GW.h)	WEIGHTED UNIT COST (cents/KW.h)
I1 Process Controls and Instrumentation	398	0.15
I2 Waste Heat Recovery	1435	0.3
I3 Motors	216	1.0
I4 Variable Speed Drives	1738	3.0
I5 Lighting	1003	3.5
I6 Electrolysis	787	4.0
I7 Refrigeration	345	4.7
TOTAL	**5922**	

FIGURE A.5.3


Electricity Conservation Supply Curve
for Ontario --Industrial Sector
Cents per kilowatt-hour
5
4
3
2
1
0
Refrigeration
Electrolysis
Lighting
Variable Speed Drives
Motors
Waste Heat
Recovery
Process
Heat
1000
2000
3000
4000
5000
6000
GWh. Saved (Relative to Year 2000 Frozen Efficiency Forecast)

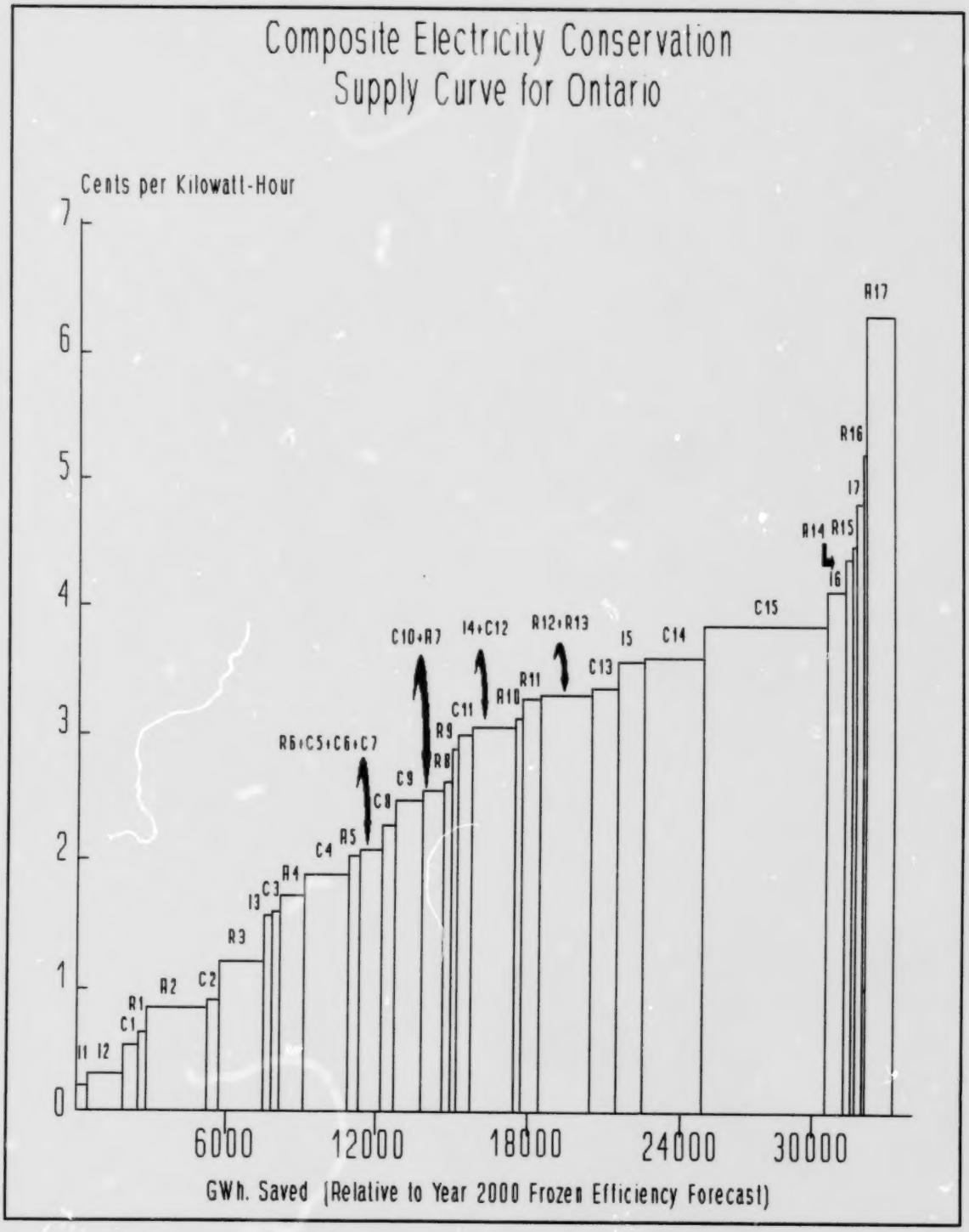
A.4.4 Composite Conservation Supply Curve

The conservation supply curves for the residential, commercial and industrial sectors are combined into one composite curve in Figure A.4.4.1. The measures are listed in order of increasing unit cost, as shown in Table A.4.4.1. As indicated, for presentation purposes, there has been some consolidation of blocks with the same unit cost.

TABLE A.4.4.1
COMPOSITE ELECTRICITY CONSERVATION SUPPLY CURVE FOR ONTARIO

BLOCK	ORIGIN	UNIT COST (cents/kwh)	SAVINGS (Gwh)
1	I1	0.15	398
2	I2	0.30	1435
3	C1	0.50	749
4	R1	0.59	202
5	R2	0.80	2700
6	C2	0.84	392
7	R3	1.13	1950
8	I3	1.50	216
9	C3	1.51	229
10	R4	1.63	1094
11	C4	1.79	1977
12	R5	1.97	258
13	R6 + C5 + C6 + C7	2.00	983
14	C8	2.21	570
15	C9	2.38	1144
16	C10 + R7	2.50	972
17	R8	2.54	276
18	R9	2.80	146
19	C11	2.98	553
20	I4 + C12	3.00	2137
21	R10	3.03	43
22	R11	3.19	704
23	R12 + R13	3.23	2245
24	C13	3.27	1131
25	I5	3.50	1003
26	C14	3.52	2566
27	C15	3.73	5164
28	I6	4.00	787
29	R14	4.28	292
30	R15	4.44	91
31	I7	4.70	345
32	R16	5.16	69
33	R17	6.20	1069
TOTAL			**33,890**

FIGURE A.5.4


Composite Electricity Conservation
Supply Curve for Ontario
Cents per Kilowatt-Hour
0
1
2
3
4
5
6
7
I1
I2
C1
R1
R2
C2
R3
I3
C3
R4
C4
R5
R5+C5+C6+C7
C8
C9
C10+R7
R8
R9
C11
I4+C12
R10
R11
R12+R13
C13
I5
C14
C15
I6
R14
R15
I7
R16
R17
6000
12000
18000
24000
30000
GWh. Saved (Relative to Year 2000 Frozen Efficiency Forecast)

A.5 CONSERVATION OF PEAK POWER

A.5.1 Electricity Conservation and Peak Power Requirements

The above discussion of conservation potential is in terms of the total amount of **energy** that can be saved **annually** by implementing various conservation measures. Electricity savings tend to fluctuate just like electricity demands, and it is often of interest to know the impact of conservation measures on power demand at different times. The most common application is to estimate peak capacity savings (and hence capital savings) that can be achieved through electricity conservation measures. In the second part of this report, where we analyze the potential of electricity conservation to reduce the amount of coal burned by Ontario Hydro, it is necessary to know the impact of conservation measures on the power demand during those times when the coal-burning generating stations are operating.

A technique is required for converting annual electricity savings from a particular conservation measure to estimates of the load reduction that would occur due to the measure during some specified time interval. The conversion from annual savings to system peak capacity savings requires a factor that is dimensionally similar to a load factor but which provides a gauge of the contribution of conservation measures to power demand reduction during different specified time periods (in the case of this analysis, during the sixteen hour peak).

To do this, we define **The System Impact Factor** of a particular conservation measure as the average power demand reduction due to the measure during the time period for which the system impacts are being measured, (eg. the 16-hour peak), divided by the average power demand reduction resulting from the measure during some specified longer time period (usually a year).

The System Impact Factor is similar to the inverse of a load factor, but measures something quite different. While a load factor (or its inverse) provides a measure of the difference between the average and maximum demand reductions from a particular measure, the System Impact Factor measures the difference between the average demand reduction from a particular measure and the impact on the total system demand during some specified time period.

The System Impact Factor as defined here is the basically the inverse of what often appears in Ontario Hydro reports as the Coincident Load Factor for a particular segment or customer class, but has several advantages.

First, the SIF is larger for those measures which have the larger impact on the system peak, which makes it intuitively easier to work with.

Second, it avoids possible confusion over the use of the term "load factor". In the narrowest, technical sense, a load factor is a ratio which describes the "peakiness" of a particular load. It is a ratio which will always be less than one, and which depends only on the characteristics of the load in question. By using the phrase "load factor" to describe the impact of a particular load during the system peak (which is what the phrase Coincident Load Factor does), the precision of the load factor definition is lost.

Third, it also avoids possible confusion over the use of the word coincidence. In the phrase Coincident Load Factor, the word coincident refers to the characteristics of the load in question at a time coincident with the system peak. But this could be confused with the "coincident" load factor of a number of independent loads, taking their "internal" coincidence (as a class) into account.

When considering energy conservation measures, it is a common expediency to replace the System Impact Factor of the conservation measure with the corresponding System Impact Factor of the end use demand itself. For example, the Coincident Load Factor of 0.3 sometimes used for space heating is really an estimate of the inverse of the 16-hour peak System Impact Factor for the space heating load itself. The implicit assumption is that the conservation measure is not more effective during the system peak than at any other time when the load is on the system, but this may not always be the case and one can imagine System Impact Factors for conservation measures that are different than the simple inverse of the corresponding end use coincident load factor.

The System Impact Factor can also be used for peak shifting measures. To take an hypothetical example, ripple controllers that turned off all the water heaters in the province from 4 p.m to 6.p.m during the winter could be considered as a measure with a two-hour peak System Impact Factor equal to the water heating demand that occurs from 4 to 6 p.m. divided by the average annual power saving corresponding to the energy saved, and would result in a very large System Impact Factor indeed.

A.5.2 Supply Curve of Peak Demand Savings

For our purposes, we are interested primarily in the impact that conservation measures will have on demand during the daily plateau in demand from about 7 a.m until 11 p.m. on winter weekdays, when the coal-fired stations are most likely to be called upon. There is very little statistical data available that allows precise estimates of System Impact Measures for different electricity conservation options. As a first attempt at constructing a supply curve of capacity savings during Ontario Hydro's "sixteen hour peak", we have assumed the System Impact Factors for different classes of conservation measures as shown in Table A.5.2.1.

TABLE A.5.2.1
SYSTEM IMPACT FACTORS AND PEAK DEMAND SAVINGS IN 2000
FOR CONSERVATION BLOCKS IN COMPOSITE SUPPLY CURVE

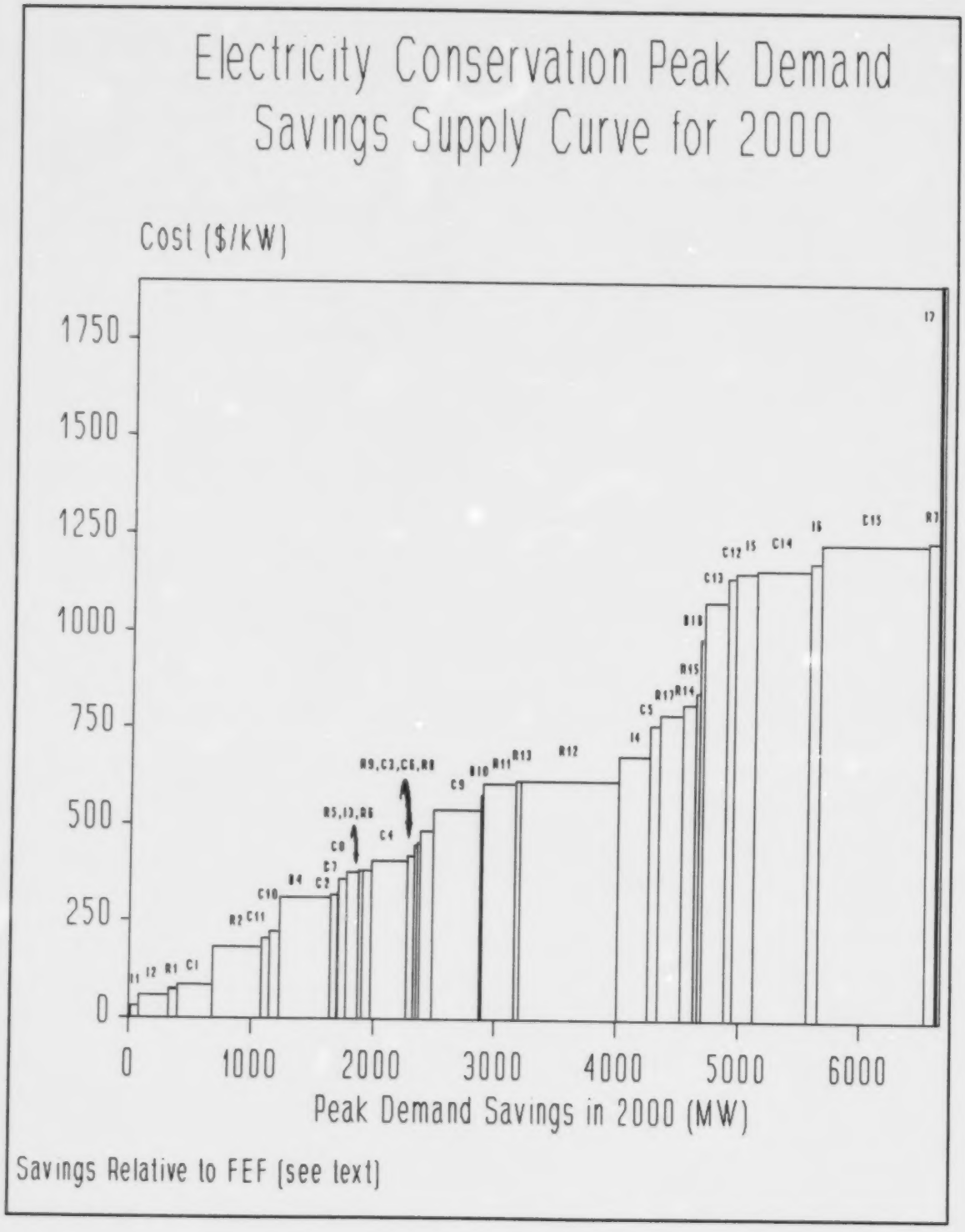
BLOCK	MEASURE	Annual Energy Savings (GW.h)	Average Power Savings (MW)	System Impact Factor	Peak Demand Savings (MW)
I1	Proc Controls	398	45	1.5	68
I2	Waste Heat Recovery	1435	164	1.5	245
C1	Space Heat Meas.	749	85	3.3	282
R1	Space Heat Meas.	202	23	3.3	77
R2	Water Heat Measures	2700	308	1.3	400
C2	EE Motors	392	45	1.3	58
R3	EE Refrigerators	1950	222	1.0	222
I3	EE Motors	216	25	1.3	32
C3	Window Glazing	229	26	1.0	26
R4	Space Heat Measures	1094	125	3.3	412
C4	Motor Balancing	1977	225	1.3	293
R5	Space Heat Measures	258	29	3.3	97
R6	Thermal Upgrade - New Apts.	204	23	3.3	77
C5	Motors - Rec. and Other Bldg	537	61	1.3	80
C6	Commercial Water Heating	172	20	1.3	25
C7	Cooling Equip. - Rec. & Other	70	8	1.0	8
C8	EE Cooling Equip.	570	65	1.0	65
C9	Motor Scheduling	1144	130	1.3	170
C10	Comm Bldg. Thermal Retrofit	222	25	3.3	84
R7	EE Freezers	750	85	1.0	85
R8	Space Heat Measures	276	31	3.3	104
R9	Window Upgrades	146	17	3.4	55
C11	Compact Fluorescents	553	63	1.0	63
I4	Variable Speed Drives	1738	198	1.3	258
C12	Commercial Lighting	399	45	1.3	59
R10	Space Heat Measures	43	5	3.3	16
R11	Space Heat Measures	704	80	3.3	265
R12	Thermal Upgrade - New SFD	2141	244	3.3	805
R13	Thermal Upgrade - New SFA	104	12	3.3	39
C13	Lighting	1131	129	1.5	193
I5	Lighting	1003	114	1.5	172
C14	Lighting	2566	293	1.5	439
C15	Lighting	5164	589	1.5	883
I6	Electrolysis	787	90	1.0	90
R14	Door Upgrades	292	33	3.3	110
R15	Space Heat Measures	91	10	3.4	34
I7	Refrigeration	345	39	1.0	39
R16	Space Heat Measures	69	8	3.3	26
R17	Lighting	1069	122	1.5	183
TOTAL/AVERAGE		33890	3863	1.7	6637

Finally, for purposes of displaying the conservation measures on a curve of peak capacity savings, we have calculated the unit investment cost for each measure in dollars per kilowatt of saved capacity and reordered the measures on the curve, starting with those measures with the lowest costs per kilowatt of saved capacity.

The resulting supply curve of saved peak demand (due to electricity conservation measures) in Ontario in the year 2000 (relative to the 1987 Frozen Efficiency Forecast) is shown in Figure A.5.5. The electricity conservation measures analyzed in this report represent a potential to reduce peak demand in the year 2000 by 6,600 MW relative to the Frozen Efficiency Forecast. The weighted average system Impact Factor for the measures is 1.72 with respect to the daily winter peak, illustrating the relative efficacy of conservation measures as peak capacity savers.

It is interesting to note the change in the order on the curve when the measures are ranked according to the cost per kilowatt of reduced peak demand rather than the cost per kilowatt-hour of saved electricity. Measures with high system impact factors (eg. space heating conservation) have much lower relative costs as demand savers than as energy savers because so much of the energy they save occurs during the winter system peak.

Figure A.5.5


Electricity Conservation Peak Demand
Savings Supply Curve for 2000
Cost ($/kW)
1750
1500
1250
1000
750
500
250
0
0
1000
2000
3000
4000
5000
6000
Peak Demand Savings in 2000 (MW)
Savings Relative to FEF (see text)

A.5.3 Displaced Capacity

The supply curve of saved peak demand does not reflect the full extent to which conservation measures can reduce the need for peak generating capacity. To arrive at a final determination of the impact of electricity conservation on the requirement for peak generating capacity, it is necessary to make allowance for the fact that the required peak capacity is greater than the actual peak demand. This is to allow for contingencies and to ensure a reliable supply of power. Furthermore, conservation options displace electricity demand **at the point of end use**, whereas supply side options deliver power to the busbar which must still be transmitted to the point of final end use. This inevitably results in transmissions and distribution losses which are typically in the range of 10-15% of the final demand for energy. Thus, a kilowatt of saved demand through conservation displaces 1.25-1.30 kilowatts of power plant capacity. For purposes of calculation we have adopted the convention used by Ontario Hydro[1] the a kilowatt reduction in peak demand due to conservation measures results in a reduction of 1.25 kilowatts of peak generating capacity.

In Table A.5.2.2. we present the figures for the displaced capacity potential that corresponds to the electricity conservation options analyzed in this study. We also show the investment costs (in dollars per displaced kilowatt) that correspond to each of the measures. These investment costs are derived from the same information that was used to calculate the unit costs of each of the measures by taking the known investment associated with a particular energy conservation measure, applying it to the displaced power savings associated with that measure. In cases where costs of saved electricity were derived without knowing the investment costs, an equivalent investment cost was derived by solving the cost annualiation formula for the initial investement, given the unit cost (in cents per kilowatt-hour, the discount rate, and the lifetime of the measure).

The resulting supply curve of displaced peak capacity potential in the year 2000 (due to the conservation measures analyzed in this report) is shown in Figure A.5.6. As the figure illustrates, the effect of allowing for the reserve margin increases the total peak capacity impact of the measures analyzed from 6,600 MW to 8,300 MW.

The unit cost of the measures as capacity displacers (as opposed to peak demand reducers) is also reduced by 20% so that the final results of the analysis show a potential for peak capacity displacement through conservation of 8,300 MW, with an average unit cost of about $1300/kW. There are a few measures which are much more expensive than the rest, and this has the effect of making the average unit cost higher than it would otherwise be. For example, 6,600 MW

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1. See for example, 1987 Bulk Electricity System Demand/Supply Report, 1987-2006, Ontario Hydro Report 661 SP, April, 1987.

of displaced capacity are available for an average unit cost of $1040/kW.

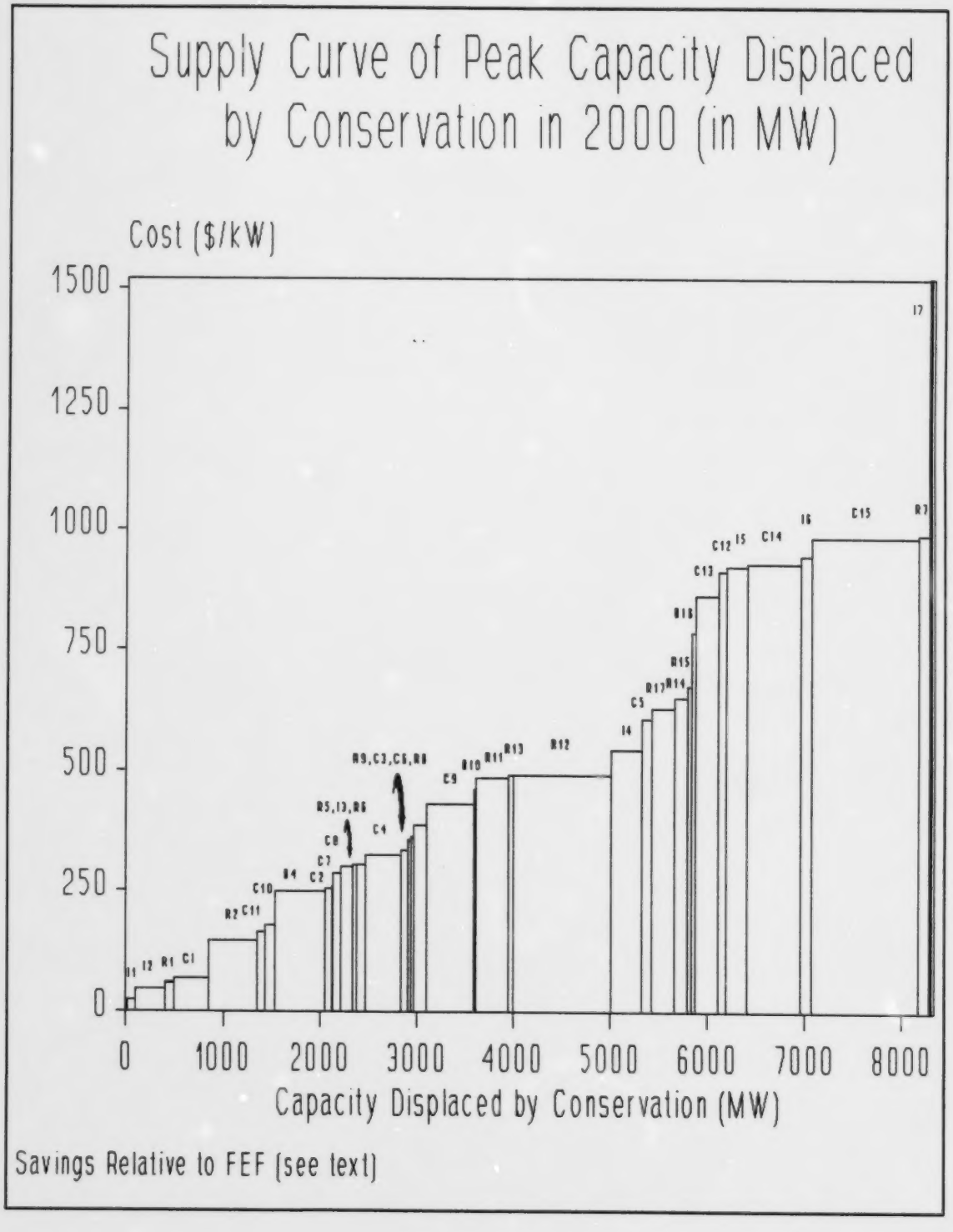
In addition to these measures, the need for peak capacity can also be reduced by measures which do not save electricity on a net basis, but which encourage users to move demand off the peak. Through time-of-use rates and other load shifting incentives, Ontario Hydro intends to move a total of 1000 MW of demand off the peak by the year 2000.

Considering that the analysis here includes only a sampling of conservation measures, it is evident that the potential for capacity displacement through electricity conservation in Ontario is very large relative to the forecast demand.

TABLE A.5.2.2
DISPLACED CAPACITY POTENTIAL FROM ELECTRICITY CONSERVATION MEASURES

BLOCK	MEASURE	Annual Energy Savings (GW.h)	Displaced Capacity (MW)	Total Displaced Capacity (MW)	Cost Per kW ($/kW)
I1	Proc Controls	398	85	85	57
I2	Waste Heat Recovery	1435	307	392	114
C1	Space Heat Meas.	749	352	744	166
R1	Space Heat Meas.	202	95	839	140
R2	Water Heat Measures	2700	500	1339	350
C2	EE Motors	392	73	1412	616
R3	EE Refrigerators	1950	278	1690	965
I3	EE Motors	216	40	1730	734
C3	Window Glazing	229	33	1762	859
R4	Space Heat Measures	1094	514	2277	599
C4	Motor Balancing	1977	366	2643	784
R5	Space Heat Measures	258	121	2764	724
R6	Thermal Upgrade - New Apts.	204	96	2860	735
C5	Motors - Rec. and Other Bldg	537	99	2960	1467
C6	Commercial Water Heating	172	32	2992	876
C7	Cooling Equip. - Rec. & Other	70	10	3002	625
C8	EE Cooling Equip.	570	81	3083	690
C9	Motor Scheduling	1144	212	3295	1042
C10	Comm Bldg. Thermal Retrofit	222	104	3399	481
R7	EE Freezers	750	107	3506	2384
R8	Space Heat Measures	276	130	3636	934
R9	Window Upgrades	146	69	3704	809
C11	Compact Fluorescents	553	79	3783	394
I4	Variable Speed Drives	1738	322	4105	1314
C12	Commercial Lighting	399	74	4179	2201
R10	Space Heat Measures	43	20	4199	1114
R11	Space Heat Measures	704	331	4530	1173
R12	Thermal Upgrade - New SFD	2141	1007	5537	1188
R13	Thermal Upgrade - New SFA	104	49	5586	1188
C13	Lighting	1131	242	5828	2079
I5	Lighting	1003	214	6042	2225
C14	Lighting	2566	548	6591	2238
C15	Lighting	5164	1104	7694	2372
I6	Electrolysis	787	112	7807	2277
R14	Door Upgrades	292	137	7944	1574
R15	Space Heat Measures	91	43	7987	1633
I7	Refrigeration	345	49	8036	3667
R16	Space Heat Measures	69	32	8068	1897
R17	Lighting	1069	228	8297	1521
TOTAL/AVERAGE		33890	3863	1.7	6637

Figure A.5.6.


Supply Curve of Peak Capacity Displaced by Conservation in 2000 (in MW)
Cost ($/kW)
1500
1250
1000
750
500
250
0
0
1000
2000
3000
4000
5000
6000
7000
8000
Capacity Displaced by Conservation (MW)
Savings Relative to FEF (see text)

A.6 CONCLUSIONS

The major conclusions to be drawn from this analysis of the potential for electricity conservation in Ontario between 1989 and 2000 are the following:

- There is an energy saving potential of at least 33,000 GWH per year by the year 2000, relative to the 1987 Frozen Efficiency Forecast, all with measures with economic costs under 5 cents per kwh. This is equivalent to 18% of Ontario Hydro's 1987 forecast of the demand for electricity in the year 2000, assuming no new conservation measures.

- This potential for electricity conservation translates to a potential peak demand reduction of 6,600 MW by 2000 or about 21% of Ontario Hydro's projected peak demand in the year 2000.

- In terms of peak capacity requirements, this peak demand saving represents about 8,300 MW. This is equivalent of 2 1/2 Darlington nuclear stations operating at 100% capacity.

- Sectoral breakdown of energy savings is:

  . Commercial 49%
  . Residential 34%
  . Industrial 17%

PART B. ELECTRICITY CONSERVATION AND ACID GAS EMISSIONS

B.1 ONTARIO HYDRO ACID GAS EMISSIONS

The smokestacks of Ontario Hydro's coal-fired generating stations emit sulphur dioxide and nitrogen oxides, the two most important contributors to the problem of acid rain. In 1987, Ontario Hydro's coal-fired plants produced 32,000 GW.h of electricity, resulting in 394,000 tonnes of acid gas pollution. In 1987, the Ontario government issued a control order[1] on Ontario Hydro that forces the utility to clean up its operations by bringing its annual acid gas emissions down below 215,000 tonnes by 1994 and keeping them there. Of the total acid gas emission ceiling of 215,000 tonnes, no more than 175,000 tonnes may be sulphur dioxide; there is no specific limit on Hydro's nitrogen oxide emissions, provided total acid gas pollution remains below the ceiling.

According to Ontario Hydro, the use of low sulphur coals will allow it to produce up to about 20,000 GW.h of coal-fired electricity without violating the regulation. As we have discussed in the first part of this report, Ontario Hydro expects to have to generate, (after allowance for purchases and its conservation and efficiency targets), about 170,000 GW.h of electricity in the year 2000, of which 37,000 GW.h would be coal-fired. Consequently, the utility has mounted a $2.5 billion remedial acid gas program that is centred around the installation of eight "scrubbers" on its largest coal burners. The eight 500 MW coal units fitted with scrubbers would generate 24,000 GW.h, with the remaining 13,000 GW.h being generated by the unscrubbed units[2].

Coal-fired stations are used to provide the peak demand for electricity (from about 7 a.m. until 11 p.m.) because they are not as capital intensive as nuclear stations and because they can be started up and shut down quickly and relatively easily in response to fluctuating demand. They are also used to provide base load power during periods of high demand (especially during the winter months and summer heat waves) and in the event of contingencies (eg. maintenance and repairs on nuclear units). For these reasons, forecast requirements for coal-fired electricity are extremely uncertain. Whatever uncertainty exists with respect to the forecast demand for energy and power, the uncertainty is magnified with respect to the

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1. Ontario Regulation 281/87, Ontario Gazette, June 13, 1987.

2. Ontario Hydro, Options Available to Meet Acid Gas Limits and Selection of Preferred Options, Report to the Lieutenant-Governor-in-Council, January 31, 1989. See also Ontario Hydro, Flue Gas Desulphurization Program -- Environmental Assessment, February, 1988.

forecast demand for coal power. Ontario Hydro's program to install eight scrubbers is based on the median forecast of electricity demand over the next 10-15 years, but coal-fired electricity requirements within the 60% confidence bounds in the load forecast range from 12 TW.h (no scrubbers would be needed) to 44 TW.h (requiring 10-12 scrubbers).

B.2 CONSERVATION AND ACID GAS EMISSIONS

In the first part of this report, we analyzed the potential effectiveness and costs of a number of conservation measures to reduce the demand for electricity and peak power in Ontario by the year 2000. In this part of the report, we analyze the impact that different levels of conservation and efficiency improvement could have on the coal burn, acid gas production and the corresponding need for scrubbers in the year 2000.

Our goal was to set three scenario levels with progressively higher levels of conservation and efficiency implementation (relative to the Frozen Efficiency Forecast) such that acid gas emissions in the year 2000 would stay below the regulated ceiling with the use of no more than six, four and two scrubbers, respectively. During the course of the analysis, a consultative workshop was held with participation from the Ontario Ministry of Energy and Ontario Hydro. At that workshop, it was decided that all the scenarios would include the assumption that the first pair of scrubbers proceeds as planned for the Lambton Generating Station.

To determine the amount of electricity that would be generated from different sources, we received the generous cooperation of Ontario Hydro's System Planning Division in running a computer simulation of the Frozen Efficiency Forecast using the **Load Management Strategy Testing Model (LMSTM)**. In this application the model was used to take a given level of demand (the Frozen Efficiency Forecast), broken into components with different load shapes, and combine it with the existing and planned system supply (including allowances for new plants, retirements, maintenance, nuclear plant retubing, etc.) to produce a breakdown of electricity production by fuel source. The model results show that the Frozen Efficiency Forecast demand of 186,000 GW.h in the year 2000 would be met with 98,300 GW.h of nuclear electricity, 37,400 GW.h of hydroelectricity, 6,500 GW.h of non-utility generation, 4,500 GW.h of oil-fired generation (Lennox), and 39,200 GW.h of coal-fired electricity.

At these levels of coal and oil-fired generation, all eight of the scrubbers in Ontario Hydro's current acid gas abatement program would be required to ensure emissions stayed below the

regulated ceiling. The results of this simulation were used, along with other Ontario Hydro system planning documents, to define the following three scenarios for more detailed analysis[1].

Scenario	No. of Scrubbers Required: (2000)	Total System Demand (2000)	Coal-fired Contribution: (2000)
Reference[2]	Eight scrubbers	186,000 GW.h	39,200 GW.h
Scenario A	Six scrubbers	170,000 GW.h	34,000 GW.h
Scenario B	Four scrubbers	165,000 GW.h	30,000 GW.h
Scenario C	Two scrubbers	160,000 GW.h	26,000 GW.h

In general, electricity conservation measures are well matched to the coal burn -- power savings on the thermal peak are about double the annual average saving. The difference in total demand between the scenarios is greater than the difference in the coal demand because a small amount of the displaced generation will be nuclear and hydro. Below 160,000 GW.h, the ratio of saved electricity to saved coal-fired electricity starts to increase rapidly.

The large drop in the total system demand between the Reference Scenario (Frozen Efficiency) and Scenario A reflects the fact that the year 2000 forecast of 186,000 GW.h (frozen efficiency) would require substantial purchases, as well as the use of the oil-fired Lennox Generating Station. It is assumed that this high cost generation would be backed out of the system before coal savings would commence.

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1. Our original intention had been to run a series of simulations using the LMSTM to further refine the level of demand in the scenarios and the impact of the conservation measures on the coal burn. This proved to be beyond the resources of the project but, fortunately, was also unnecessary for the level of specification required, given the uncertainty in the coal burn and the load shapes of the conservation and efficiency measures included in the scenarios.

2. The reference scenario is based on the electricity demand associated with the Frozen Efficiency Forecast; it is also about equal to the 1988 Basic Forecast. Scenario A is for a demand level of about 170,000 GW.h, which is close to Ontario Hydro's current Primary Forecast for the year 2000. The number of scrubbers included in each scenario is relative to the reference case (eight scrubbers), and based on the fact that up to about 20,000 GW.h can be generated with low sulphur coal in unscrubbed plants without exceeding the limits. The actual number of scrubbers installed for a particular demand level may be higher, depending on the perceived need for a contingency margin. Ontario Hydro has proposed a large safety margin be used in the planning of scrubbers to allow for unexpectedly high coal burns. For example, although a demand level of 170,000 GW.h in 2000 could be met with six scrubbers, Ontario Hydro proposes a total of eight scrubbers for this level of forecast demand.

B.3 SCENARIOS OF ELECTRICITY CONSERVATION

The supply curves of electricity conservation developed in Part A of this report can be used to determine the cost and effectiveness of conservation as an option for reducing acid gas emissions. For purposes of analyzing this potential in more detail, we established a data base of conservation measures which includes all of the measures analyzed in Part A that have a unit cost of saved electricity of less than four cents per kilowatt-hour. This results in a conservation data base, as shown in Table B.1, which does not include the six most expensive measures, but which still adds up to a total of 31,237 GW.h electricity savings or a potential to displace up to 7,694 of peak generating capacity in the year 2000.

Table B.1 also contains financial information about the conservation measures. The total investment to fully realize the potential for each measure is shown, along with the amortization period. This data is combined with the data for peak power savings and displaced peak capacity to yield the final two columns, investment per kilowatt of peak demand reduction and investment per kilowatt of displaced capacity. A comparison of these final two columns with the unit cost data in the first column shows how the ranking of the measures changes depending on whether it is based on unit costs for saved energy or unit investment costs for saved peak power or capacity.

It is important to realize that the costs of conservation shown in Table B.1 (and throughout this report) are **total** or **economic** costs (in 1987 dollars) and not just the portion of the cost Ontario Hydro might associate with these same conservation measures. The data in Table B.1 indicate that to implement all 7,700 MW of conservation peak capacity would require a total investment of $9.451 billion at an average cost per displaced kilowatt of $1228.

Table B.1 Database for Electricity Conservation Scenarios

Block	Measure	Unit Cost (cents/ kWh.)	Annual Savings (GW.h) in 2000	Total Energy Savings (GW h)	System Impact Factor	Average Power Savings in 2000 (MW)	Peak Power Savings in 2000 (MW)	Total Peak Savings (MW)	Displaced Peak Capacity in 2000 (MW)	Total Displaced Capacity (MW)	Amort. Period (years)	Total Investment (millions $)	Cumulative Investment (millions $)	Investment per KW Peak $/kW	Investment per KW Displaced $/kW
I1	Proc. Controls/Instrumentation	0.15	398	398	1.5	45	68	68	85	85	10	5	5	71.15	56.92
I2	Waste Heat Recovery	0.30	1435	1833	1.5	161	245	313	307	392	10	35	40	142.30	113.84
C1	Space Heating -- New Buildings	0.50	749	2582	3.3	85	282	595	352	744	25	59	98	207.63	166.11
R1	Pre-81 Apts. Thermal Retrofit	0.59	202	2784	3.3	23	76	671	95	839	15	13	112	174.37	139.50
R2	Water Heating Savings	0.80	2700	5484	1.3	308	400	1071	500	1339	10	175	287	437.84	350.27
C2	Energy Efficient Motors	0.84	392	5876	1.3	45	58	1129	73	1412	20	45	331	770.31	616.25
R3	Efficient Refrigerators	1.13	1950	7826	1.0	222	222	1352	278	1690	17	268	600	1205.90	964.72
I3	Efficient Industrial Motors	1.00	216	8042	1.3	25	32	1384	40	1730	20	29	629	917.03	733.63
C3	Window Glazing - Comm. Bldg.	1.51	229	8271	1.0	26	26	1410	33	1762	10	28	657	1074.35	859.48
R4	SFD Insulation Retrofit (pre-81)	1.63	1094	9365	3.3	125	412	1821	514	2277	30	308	965	749.24	599.39
C4	Comm Bldg. Motors Balancing	1.79	1977	11342	1.3	225	293	2114	366	2643	10	287	1252	979.66	783.73
R5	SFD Infiltration Retrofit (Pre-81)	1.97	258	11600	3.3	29	97	2211	121	2764	30	88	1340	905.52	724.41
R6	New Apartments - Thermal Upgrad	2.00	204	11804	3.3	23	77	2288	96	2860	30	71	1411	919.31	735.45
C5	Motors -- Recreational & Other Bld	2.00	537	12341	1.3	61	80	2368	99	2960	20	146	1557	1834.07	1467.25
C6	Commercial Water Heating Conserv	2.00	172	12513	1.3	20	25	2393	32	2992	10	28	1585	1094.60	875.68
C7	Cooling Equip. - Rec. & Other	2.00	70	12583	1.0	8	8	2401	10	3002	5	6	1591	781.03	624.82
C8	High Efficiency Cooling Equipment	2.21	570	13153	1.0	65	65	2466	81	3083	5	56	1647	863.04	690.43
C9	Motor Scheduling	2.38	1144	14297	1.3	130	170	2636	212	3295	10	221	1868	1302.57	1042.06
C10	Commercial Buildings Thermal Retr	2.50	222	14519	3.3	25	84	2719	104	3399	10	45	1913	539.01	431.20
R7	Energy Efficient Freezers	2.50	750	15269	1.0	85	85	2805	107	3506	20	255	2168	2980.36	2384.29
R8	SFA Retrofit -- Pre-81	2.54	276	15545	3.3	31	104	2909	130	3636	30	121	2289	1167.52	934.02
R9	SFD Window Upgrades	2.80	146	15691	3.3	17	55	2964	69	3704	20	56	2344	1011.52	809.21
C11	Compact Fluorescents	2.96	553	16244	1.0	63	63	3027	79	3783	2	31	2375	493.04	394.43
I4	Variable Speed Drives	3.00	1738	17982	1.3	198	258	3284	322	4105	10	423	2798	1641.89	1313.52
C12	Commercial Lighting	3.00	399	18381	1.3	45	59	3343	74	4179	20	163	2961	2751.10	2200.88
R10	SFA Thermal Retrofit (81-90 Stock)	3.03	43	18424	3.3	5	16	3359	20	4199	30	23	2984	1392.75	1114.20
R11	SFD Insulation Retrofit (Pre-81 Stoc	3.19	704	19128	3.3	80	265	3624	331	4530	30	386	3372	1466.30	1173.04
R12	SFD Thermal Upgrade -- New Hom	3.23	2141	21269	3.3	244	805	4430	1007	5537	30	1196	4568	1484.68	1187.75
R13	SFA Thermal Upgrade -- New Hom	3.23	104	21373	3.3	12	39	4469	49	5586	30	58	4626	1484.68	1187.75
C13	Commercial Lighting -- Level II	3.27	1131	22504	1.5	129	193	4662	242	5828	20	503	5128	2598.87	2079.10
I5	Industrial Lighting	3.50	1003	23507	1.5	114	172	4834	214	6042	20	477	5606	2781.67	2225.33
C14	Level III Lighting in New Stock	3.52	2566	26073	1.5	293	439	5273	548	6591	20	1228	6833	2797.56	2238.05
C15	Level III Lighting Retrofit	3.73	5164	31237	1.5	589	883	6156	1104	7694	20	2618	9451	2964.46	2371.57

The next step in our analysis of the contribution conservation and efficiency could make to reducing Ontario Hydro's acid gas emissions in 2000 is to design three conservation scenarios, based on the data in Table B.1. As discussed above, we require three scenarios of progressively higher levels of conservation -- Scenarios A, B and C -- which can reduce the demand for electricity, relative to the Frozen Efficiency Forecast, in the year 2000, by 16,000 GW.h, 21,000 GW.h, and 26,000 GW.h, respectively.

The cost of achieving a given level of conservation is strongly dependent on the mix of measures that are included. For example, one way to achieve a given level of conservation is to start with the cheapest measures (in terms of unit energy cost) and work up the supply curve, totally using up one measure before moving on to the next, until the total energy savings equal the target. This method, which could be called the "saturation" method, will yield the least cost strategy for achieving the target, but it requires the unrealistic assumption that 100% implementation of potential is possible for each measure. Another way is to assume that all of the measures in the data base are implemented simultaneously up to the level necessary to achieve the target. This method, which could be called the "proportional" method, will yield a higher cost set of measures but requires lower implementation levels for each of the measures.

We have used these two methods to define the range of costs associated with achieving our scenario levels of conservation. For example, to achieve a total of 16,000 GW.h of conservation in 2000 (Scenario A), we can either use all of the measures listed in Table B.1 up to and including C11 (Compact Fluorescents in commercial buildings), for a total of 16,244 GW.h of saved electricity in the year 2000; or we can assume a 51% penetration of all the measures listed in Table B.1, for a total of 15,930 MW. The first approach has a total investment cost of $2.38 billion and the second approach has a total cost of $4.82 billion, highlighting the sensitivity of total Scenario costs to the way the program is designed and the mix of measures that are employed. This approach was applied to each of the three scenarios to yield both a low cost and a high cost version of each conservation target level. For the high cost scenarios, penetration rates of 51%, 67% and 83% are required for Scenarios A, B, and C, respectively.

Finally, two different implementation rates were run for each variation of each scenario -- one in which the scenario is implemented in ten equal steps starting in 1990 and continuing through 1999, and the other in which implementation in the first year is 7% of the total scenario and gradually accelerates to 15% in 1999. This variation in implementation rate is included to permit analysis of the variation in the value of the plans under different implementation rates -- costs will not be affected by implementation rates as all dollar figures

are presented in constant 1987 dollars, net of inflation. The scenarios and the variations on the costs and the implementation rates are summarized in Table B.2.

The "Residual Energy Savings" referred to in Table B.2 requires some explanation. The conservation measures that make up the scenarios in Table B.2 have amortization periods ranging from two years to thirty years. This means that by the year 2000, the time horizon of our scenarios, most of the measures will only be part way through their economic life. The "residual" energy savings shown represent the sum over all the measures of the amount of energy that will be saved after the year 2000 as a result of the investments made in the 1990-1999 time period represented by these conservation plans. We are making the conservative assumption that the conservation measures "purchased" with the investments included in these scenarios will only save energy for the financial lifetime of the investment. These residual energy savings form an important component of the total value of the conservation scenarios, as we discuss below.

TABLE B.2 SUMMARY OF ELECTRICITY CONSERVATION SCENARIOS AND IMPLEMENTATION RATES

	Scenario A		Scenario B		Scenario C	
	Low Cost	High Cost	Low Cost	High Cost	Low Cost	High Cost
Number of scrubbers in 2000	6	6	4	4	2	2
Energy Savings in 2000 (GW.h)	16,244	15,931	21,269	20,930	26,073	25,927
Displaced Capacity in 2000 (MW)	3,783	3924	5,537	5,155	6,590	6,386
Implementation by Equal Steps:						
Annual Investment (millions $)	238	482	457	633	683	784
Total Investment (billions $)	2.38	4.82	4.57	6.33	6.83	7.84
Cumulative Energy Savings to 2000 (TW.h)	89	88	117	115	143	143
Residual Energy Savings in 2000 (in TW.h)	194	238	255	235	316	306
Implementation Rate Accelerates						
1990 Investment (millions $)	166	337	320	443	478	549
1999 Investment (millions $)	356	723	685	950	1025	1177
Total Investment (billions $)	2.38	4.82	4.57	6.33	6.83	7.84
Cumulative Energy Savings to 2000 (TW.h)	78	76	102	100	125	124
Residual Energy Savings in 2000 (TW.h)	205	238	270	249	334	324

B.4 ECONOMIC ANALYSIS

We started out with the objective of analyzing the cost and effectiveness of electricity conservation and efficiency improvements as an alternative to scrubbers for reducing Ontario Hydro's acid gas emissions in the 1990's. In Part A of the report, we developed supply curves of electricity conservation relative to the 1987 Frozen Efficiency Forecast. In Part B, we have used these supply curve to develop electricity conservation scenarios that would result in reduced coal burning on the Ontario Hydro system in the 1990's, with a corresponding drop in acid gas emissions. The three scenarios we developed (with a total of twelve variations) specify conservation measures and implementation rates that would be sufficient to reduce the coal burn in 2000 by enough to displace up to six scrubbers.

In this final section of the report, we analyze the economics of these scenarios and compare them to the reference scenario (no new conservation, eight scrubbers) as a means for reducing acid gas emissions in the 1990's.

Expressed in 1987$, (dollar amounts are expressed in 1987 dollars throughout this analysis), the capital cost of scrubbers is approximately $100 million and the annual operating and maintenance costs an additional $5 million[1]. The total capital and operating costs of a full program of eight scrubbers brought on line during the 1990's would be in the neighbourhood of $1 billion by the year 2000. As can be seen from the data in Table B.2, a simple comparison of scrubber costs with the economic cost of conservation investments shows that scrubbers are a relatively inexpensive way to reduce acid gas emissions, *all else being equal.*

All else is not equal, however; conservation and efficiency investments produce numerous other benefits in the form of saved energy costs and deferred capital investments, and a comprehensive valuation of the conservation scenarios in Table B.2 is required to adequately consider the economic potential of conservation and efficiency improvements as acid gas abatement measures. We have estimates of the total economic investment costs associated with different levels of conservation (relative to the Frozen Efficiency Forecast); what we require is some estimate of the benefit or the value associated with those conservation investments.

One approach to this analysis is to use computer models to simulate the Ontario Hydro system under different conservation scenarios with varying system impact factors. Models such as

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1. Ontario Hydro, Options Available to Meet Acid Gas Limits and Selection of Preferred Options, report to the Lieutenant Governor in Council, January 31, 1989.

the Load Management Simulation Testing Model (LMSTM) can be used to estimate the total cost of operating the electricity system under different demand scenarios.

Given the degree of estimation in our data and the scenario approach to our analysis, we need only a simple tool for estimating the approximate value of the conservation scenarios, and for this purpose we have used Ontario Hydro's System Values. The System Values are a set of dollar values associated with incremental changes to the total system demand for electricity or peak power. While they are intended primarily for estimating the value of small increments of conservation or additional supply, they can be used to approximate the value of deferred capital investment and saved energy costs associated with our conservation scenarios. The incremental system values of saved power and energy used in this analysis are based on Ontario Hydro data.[1]

The value of conservation measures which defer the need for peak capacity is essentially the value to Ontario Hydro of being able to delay investments in new generating stations. For saved power, the system values are expressed in dollars per kilowatt of winter peak demand and are discounted to January 1 of the starting year. The present value of a capacity deferral measure depends on how long it lasts and when it begins. In the early to mid 1990's, the system values are based on the capacity-related part of the OM&A costs of fossil-fired stations and the full lifecycle costs of providing new capacity resources. In the late 1990's and beyond, the system values for saved peak capacity reflect the full life cycle costs of a representative mix of new resources.

The system values for saved energy are expressed in the Ontario Hydro tables in mills/kW.h of the year (although we have deflated all dollars to 1987). The proportions of incremental generation sources (such as coal, oil and uranium) projected for different years are multiplied by the value of the energy generated from these sources to arrive at the system values for saved energy. The costs of various acid gas emission control measures are included as part of the cost of coal-generated electricity. It is assumed that when supplying incremental capacity and energy demand, the acid gas emission control costs are represented by low sulphur coal premiums (about 1 % sulphur) to the year 1993 and by scrubbing 2.5% sulphur coal thereafter. The scrubber capital and OM&A costs are included in the energy system values. The scrubber variable cost have been adjusted to take into account the additional scrubbing necessary to

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1. Ontario Hydro, Incremental System Values of Power and Energy, "Provision of Energy Prediction 7.2.7", Demand Supply Integration Department, March 1989. The system values in this report are relative to the 1988 Basic Forecast; we have applied them to the 1987 Frozen Efficiency Forecast without adjustment on the basis of the close agreement between the 1988 Basic and 1987 FEF forecasts. The system values themselves with accompanying explanatory notes are included as Appendix IV.

maintain the same level of acid gas emission before and after the addition of an energy increment. With respect to nuclear energy, it is assumed that in the long term a fraction of the nuclear energy that is in excess of primary demand can be marketed for a price in excess of its incremental production cost.

The system values described above were incorporated into a model that tracks the implementation of all the scenario variations on a year-by-year basis from 1991 to 2030. Our immediate focus is on the 1990-2000 time period, but the model must run out to 2030 to capture the residual energy savings of conservation measures implemented during the 1990-2000 time period but which continue to deliver energy savings beyond 2000.

Some of the data from this model are shown in Appendix II. For each scenario variation, two implementation rates were evaluated -- one in which the year 2000 target savings are approached in ten equal steps starting in 1991 and one in which the same year 2000 target is approached with an accelerating implementation rate that starts out at 7% of the target in 1991 and rises to 15% of the target in the tenth and final year. System values for power and energy were developed for each scenario variation and implementation rate and used to calculate the total value of each scenario variation for each year from 1990 to 2000 for each implementation rate.

Finally, the residual energy savings in the year 2000 for each scenario variation and implementation rate were calculated by tracking each of the conservation measures to the year 2030 and computing energy savings for each year on the assumption that the measures cease to deliver energy savings at the end of their amortization period. These energy savings were then multiplied by the appropriate system values (in 1987$) and discounted to the year 2000 so that the value of residual energy savings can be included in the 1990-2000 economic analysis as a residual expressed in terms of its present value in the year 2000.

The results of this analysis are shown in Table B.3 for each of the scenario variations and each of the implementation rates. The data in Table B.3 can be read like a cash flow analysis, with the conservation investments representing outlays and the system values representing incomes, but in it is important to realize the table does not represent an actual cash flow projects. The system values represent the savings to Hydro of the stated levels of energy and peak power conservation but the costs to achieve the savings are estimates of the total economic costs. In addition, the dollar figures have not been discounted to some common point in time as they would be in a cash flow analysis, but are presented as present values in the year for which they are entered. Each scenario variation is valued at the equal step

implementation rate (10% per year from 1991-2000) and at the accelerating implementation rate (7% in 1991 growing to 15% by 2000). The investments associated with the conservation scenario are shown in the first row, followed by the system values for deferred capacity and for saved energy respectively. In the **Total** column, the value of the residual energy savings is added in to yield an overall estimate of the net economic gain associated with each of the scenario variations. All dollar figures are expressed in 1987$.

Notwithstanding the simplicity of this approach, the results are clear. In every case, the total economic investment costs of the conservation scenarios are less than the related Ontario Hydro system values for saved energy and power and residual energy savings. The implementation rate variations considered here have only minor impacts on the net economic gain associated with a particular scenario, but there is a large difference in the net economic gain associated with the "saturation" approach (low cost) and the "proportional" approach (high cost). The data in Table 7.3 also show the importance of including the value of the residual savings, although all of the scenario variations would show a net economic gain over the decade even without credit for the residual savings.

Table B.3

ECONOMIC ANALYSIS OF CONSERVATION SCENARIOS

(All figures in millions of 1987$)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	TOTAL
Scenario A -- Low Cost Variation:												
Equal Step Implementation												
Conservation Investment	(238)	(238)	(238)	(238)	(238)	(238)	(238)	(238)	(238)	(238)		(2,380)
System Value of Deferred Capacity		181	196	211	227	215	272	280	299	320	338	2,539
System Value of Saved Energy		25	49	70	95	149	211	253	305	341	389	1,886
Value of Residual Energy Savings												3,561
Net Economic Gain	(238)	(32)	7	43	84	125	245	295	366	423	728	5,606
Accelerating Implementation:												
Conservation Investment	(166)	(166)	(190)	(190)	(214)	(238)	(261)	(285)	(309)	(356)		(2,375)
System Value of Deferred Capacity		127	137	169	182	193	271	308	359	416	508	2,669
System Value of Saved Energy		18	34	51	71	116	172	217	274	322	389	1,665
Value of Residual Energy Savings												3,642
Net Economic Gain	(166)	(22)	(19)	30	39	71	182	240	324	382	897	5,601
Scenario B -- Low Cost Variation												
Equal Step Implementation:												
Conservation Investment	(457)	(457)	(457)	(457)	(457)	(457)	(457)	(457)	(457)	(457)		(4,570)
System Value of Deferred Capacity		312	333	357	380	375	441	457	485	515	539	4,193
System Value of Saved Energy		33	65	92	124	195	276	332	399	446	510	2,470
Value of Residual Energy Savings												4,043
Net Economic Gain	(457)	(112)	(59)	(9)	47	113	260	331	427	504	1,048	6,136
Accelerating Implementation:												
Conservation Investment	(320)	(320)	(365)	(365)	(411)	(457)	(502)	(548)	(594)	(685)		(4,567)
System Value of Deferred Capacity		218	233	285	304	337	441	502	582	669	808	4,381
System Value of Saved Energy		23	45	67	93	152	225	284	359	421	510	2,180
Value of Residual Energy Savings												4,233
Net Economic Gain	(320)	(79)	(87)	(12)	(14)	32	165	239	347	405	1,318	6,227
Scenario C -- Low Cost Variation												
Equal Step Implementation:												
Conservation Investment	(683)	(683)	(683)	(683)	(683)	(683)	(683)	(683)	(683)	(683)		(6,830)
System Value of Deferred Capacity		378	404	432	460	459	533	551	585	621	651	5,073
System Value of Saved Energy		40	79	112	152	239	338	407	489	547	625	3,028
Value of Residual Energy Savings												5,009
Net Economic Gain	(683)	(264)	(200)	(139)	(71)	15	188	275	391	484	1,275	6,280
Accelerating Implementation:												
Conservation Investment	(478)	(478)	(547)	(547)	(615)	(683)	(752)	(820)	(888)	(1,025)		(6,833)
System Value of Deferred Capacity		265	283	345	368	413	533	607	702	807	976	5,298
System Value of Saved Energy		28	55	82	114	186	276	349	440	517	625	2,672
Value of Residual Energy Savings												5,244
Net Economic Gain	(478)	(185)	(209)	(119)	(133)	(83)	57	135	254	298	1,601	6,381

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Table B.3 (cont'd.)

ECONOMIC ANALYSIS OF CONSERVATION SCENARIOS

(All figures in millions of 1987$)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	TOTAL
Scenario A -- High Cost Variation												
Equal Step Implementation:												
Conservation Investment	(482)	(482)	(482)	(482)	(482)	(482)	(482)	(482)	(482)	(482)		(4,820)
System Value of Deferred Capacity		241	257	275	293	295	339	351	372	395	415	3,234
System Value of Saved Energy		25	48	69	93	146	207	248	299	334	382	1,850
Value of Residual Energy Savings												2,932
Net Economic Gain	(482)	(216)	(176)	(138)	(96)	(41)	64	118	189	247	796	3,197
Accelerating Implementation:												
Conservation Investment	(337)	(337)	(386)	(386)	(434)	(482)	(530)	(578)	(627)	(723)		(4,820)
System Value of Deferred Capacity		169	180	220	234	266	339	386	447	513	622	3,377
System Value of Saved Energy		17	34	50	70	114	169	213	269	316	382	1,633
Value of Residual Energy Savings												3,031
Net Economic Gain	(337)	(151)	(172)	(115)	(130)	(102)	(22)	21	89	106	1,004	3,221
Scenario B -- High Cost Variation												
Equal Step Implementation:												
Conservation Investment	(633)	(633)	(633)	(633)	(633)	(633)	(633)	(633)	(633)	(633)		(6,330)
System Value of Deferred Capacity		299	319	341	363	366	420	435	461	489	514	4,008
System Value of Saved Energy		32	63	90	122	192	271	326	392	439	501	2,431
Value of Residual Energy Savings												3,656
Net Economic Gain	(633)	(301)	(250)	(202)	(148)	(75)	58	128	221	295	1,015	3,765
Accelerating Implementation:												
Conservation Investment	(443)	(443)	(507)	(507)	(570)	(633)	(697)	(760)	(823)	(950)		(6,333)
System Value of Deferred Capacity		209	223	273	291	330	420	479	554	636	771	4,185
System Value of Saved Energy		23	44	66	91	150	222	280	353	415	501	2,145
Value of Residual Energy Savings												3,858
Net Economic Gain	(443)	(211)	(239)	(168)	(188)	(154)	(55)	(2)	84	101	1,272	3,855
Scenario C -- High Cost Variation												
Equal Step Implementation:												
Conservation Investment	(784)	(784)	(784)	(784)	(784)	(784)	(784)	(784)	(784)	(784)		(7,840)
System Value of Deferred Capacity		370	395	423	450	454	521	539	572	606	637	4,966
System Value of Saved Energy		40	79	112	151	237	336	404	486	544	621	3,011
Value of Residual Energy Savings												4,807
Net Economic Gain	(784)	(373)	(310)	(250)	(183)	(93)	73	159	274	366	1,258	4,944
Accelerating Implementation:												
Conservation Investment	(549)	(549)	(628)	(628)	(706)	(784)	(863)	(941)	(1,020)	(1,177)		(7,845)
System Value of Deferred Capacity		259	277	338	360	408	521	593	686	788	955	5,184
System Value of Saved Energy		28	55	82	113	185	274	347	438	514	621	2,657
Value of Residual Energy Savings												5,048
Net Economic Gain	(549)	(262)	(296)	(208)	(233)	(190)	(68)	(2)	103	125	1,576	5,045

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B.5 CONCLUSIONS

Part A of this report has shown that when the economic costs of conservation and efficiency investments are calculated using the same methods used to calculate the unit price of electricity from power plants, the result is a very large potential for efficiency improvement with economic costs that compare very favourably with the costs to Ontario Hydro of increasing its capacity to deliver electricity to the point of end use. In Part B, we analyzed several scenarios of electricity conservation (relative to the frozen efficiency forecast of Ontario Hydro) and have found that within the economic potential for electricity conservation identified in Part A, there is also the potential to:

- reduce the output of coal-fired plants throughout the 1990's to the point where acid gas emission targets can be met without the construction of up to 6 scrubbers;
- displace the need for new generating capacity at total economic costs significantly less than the internal value of the savings to Ontario Hydro;
- produce a stream of net economic benefits which are positive within the decade and overwhelming when post-2000 imbedded savings are taken into account.

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APPENDIX I

STATISTICAL TABLES, FROZEN EFFICIENCY FORECAST
ELECTRICITY USE IN ONTARIO, YEAR 2000

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TABLE I.1

ONTARIO RESIDENTIAL SPACE HEAT IN 2000 – FROZEN EFFICIENCY FORECAST

SINGLE FAMILY DETACHED DWELLINGS

Vintage	Stock (10e6)	Per Household Tertiary Energy		Resistance Heat share			Heat Pump Share			Total Electric
		GJ	kW.h	%	Units (000'S)	GW.H	%	Units (000'S)	GW.H	Heat (GW.H)
Pre-1981	1.71	85	23630	18	309	7294	4	69	648	7942
1981-90	0.39	71	19608	23	88	1722	12	45	352	2075
1991-2000	0.45	70	19460	28	126	2444	25	114	884	3328
Total/Ave	2.55	80	22282	20	522	11461	9	227	1884	13345

SINGLE FAMILY ATTACHED DWELLINGS

Vintage	Stock (10e6)	Per Household Tertiary Energy		Electric Heat share		TOTAL
		GJ	kW.h	%	Units (000'S)	GW.H
Pre-1981	0.4495	36	10008	20	90	900
1981-90	0.0774	35	9730	24	18	178
1991-2000	0.0708	30	8340	27	19	162
Total/Ave	0.5978	35	9774	21	128	1240

APARTMENTS

Vintage	Stock (10e6)	Per Household Tertiary Energy		Electric Heat share		TOTAL
		GJ	kW.h	%	Units (000'S)	GW.H
Pre-1981	0.8077	30	8340	20	162	1347
1981-90	0.1927	30	8340	27	53	440
1991-2000	0.2294	25	6950	46	105	730
Total/Ave	1.2299	29	8081	26	319	2518

SUMMARY

RESISTANCE HEAT	15218 GW.H
HEAT PUMP	1884 GW.H
TOTAL ELECTRIC HEAT	17103 GW.H

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TABLE I.2

ELECTRICITY SPECIFIC END USE IN THE RESIDENTIAL SECTOR IN 2000

FROZEN EFFICIENCY FORECAST
TOTAL ENERGY USE BY YEAR AND END USE

END USE	1985 (PJ)	1986 (PJ)	1987 (PJ)	1988 (PJ)	1989 (PJ)	1990 (PJ)	1991 (PJ)	1992 (PJ)	1993 (PJ)	1994 (PJ)	1995 (PJ)	1996 (PJ)	1997 (PJ)	1998 (PJ)	1999 (PJ)	2000 (PJ)
Lighting	8.43	8.54	8.75	8.95	9.14	9.33	9.54	9.74	9.93	10.13	10.32	10.50	10.68	10.84	10.98	11.12
Stove	12.42	12.62	12.97	13.30	13.63	13.96	14.32	14.67	15.03	15.39	15.75	16.08	16.40	16.70	16.98	17.25
Fridge	13.79	13.99	14.32	14.64	14.95	15.25	15.58	15.91	16.24	16.56	16.87	17.17	17.45	17.72	17.96	18.19
Freezer	6.14	6.31	6.55	6.79	7.04	7.28	7.55	7.83	8.11	8.39	8.67	8.95	9.22	9.49	9.76	10.01
Air conditioner	1.44	1.48	1.53	1.59	1.64	1.70	1.76	1.82	1.88	1.94	2.00	2.06	2.12	2.18	2.23	2.29
Dishwasher	0.83	0.89	0.97	1.04	1.12	1.19	1.30	1.40	1.51	1.62	1.73	1.85	1.96	2.08	2.20	2.31
Dryer	6.61	6.89	7.04	7.19	7.33	7.47	7.73	8.00	8.26	8.53	8.80	9.06	9.32	9.57	9.82	10.06
Washer	0.70	0.71	0.73	0.75	0.77	0.79	0.81	0.83	0.85	0.86	0.88	0.90	0.92	0.94	0.95	0.97
TV/Radio	5.94	6.00	6.16	6.14	6.47	6.62	6.77	6.93	7.08	7.24	7.39	7.54	7.67	7.80	7.93	8.04
Aux space heating	8.18	8.56	8.99	9.42	9.86	10.30	10.77	11.24	11.73	12.22	12.72	13.21	13.70	14.19	14.67	15.14
Other electric	5.54	5.78	6.05	6.33	6.60	6.88	7.22	7.57	7.92	8.28	8.65	9.01	9.37	9.73	10.08	10.43
TOTAL	70.02	71.77	74.06	76.13	78.55	80.77	83.35	85.92	88.54	91.15	93.78	96.33	98.82	101.24	103.55	105.81
No. of Households	3.27	3.34	3.42	3.51	3.59	3.67	3.75	3.83	3.91	3.99	4.06	4.13	4.20	4.27	4.33	4.38

PER HOUSEHOLD ELECTRICITY SPECIFIC ENERGY USE IN 2000, FEF

END USE	1985 kW.h	1986 kW.h	1987 kW.h	1988 kW.h	1989 kW.h	1990 kW.h	1991 kW.h	1992 kW.h	1993 kW.h	1994 kW.h	1995 kW.h	1996 kW.h	1997 kW.h	1998 kW.h	1999 kW.h	2000 kW.h
Lighting	716	711	710	709	708	707	707	707	707	707	706	706	706	706	706	706
Stove	1056	1051	1053	1054	1055	1057	1061	1065	1069	1074	1078	1081	1085	1088	1091	1094
Fridge	1172	1165	1162	1160	1157	1155	1155	1155	1155	1155	1154	1154	1154	1154	1154	1154
Freezer	522	525	532	538	545	551	560	568	577	585	593	602	610	618	627	635
Air conditioner	123	123	124	126	127	128	130	132	133	135	137	138	140	142	143	145
Dishwasher	71	74	78	82	86	90	96	102	107	113	119	124	130	136	141	147
Dryer	562	573	571	569	568	566	573	580	588	595	602	609	616	624	631	638
Washer	59	59	60	60	60	60	60	60	60	60	60	61	61	61	61	61
TV/Radio	505	500	500	486	501	501	502	503	504	505	506	507	507	508	509	510
Aux space heating	696	713	730	747	763	780	798	816	834	852	870	888	906	924	943	961
Other electric	471	481	491	501	511	521	535	549	564	578	592	606	620	634	648	662
Per Household Total	5953	5977	6012	6033	6082	6117	6178	6237	6299	6359	6418	6476	6536	6596	6654	6713

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Table 1.3
ELECTRICITY USE IN 1989 VINTAGE COMMERCIAL BUILDING STOCK IN 2000
FROZEN EFFICIENCY FORECAST

BUILDING TYPE	FLOOR AREA (sqm(10e6))	LIGHTING	COOLING	AUXILIARY			SPACE	WATER	TOTAL
				Motors	Equip	Total Auxiliary			
Elementary School	10.6								
Energy Intensity (MJ/sqm)		135.50	50.36	96.80	21.09	117.89	828.00	39.89	1171.65
Energy Intensity (kW.h/sqm)		37.67	14.00	26.91	5.86	32.77	230.18	11.09	325.72
Electric Share		1.00	1.00	1.00	1.00		0.07	0.09	
Electricity Subtotal (GW.h)		398.93	148.26	284.98	62.10	347.08	170.64	10.84	1075.74
Heat Pump Share			0.00				0.02	0.02	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				12.19	0.59	12.78
Total Electricity (GW.h)		398.93	148.26	284.98	62.10	347.08	182.82	11.43	1088.51
Secondary School	4.6								
Energy Intensity (MJ/sqm)		185.86	50.36	121.98	31.64	153.62	828.00	39.89	1257.73
Energy Intensity (kW.h/sqm)		51.67	14.00	33.91	8.80	42.71	230.18	11.09	349.65
Electric Share		1.00	1.00	1.00	1.00		0.07	0.09	
Electricity Subtotal (GW.h)		236.13	63.98	154.97	40.20	195.17	73.64	4.68	573.59
Heat Pump Share			0.00				0.07	0.02	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				18.41	0.25	18.66
Total Electricity (GW.h)		236.13	63.98	154.97	40.20	195.17	92.04	4.93	592.26
Colleges	1.4								
Energy Intensity (MJ/sqm)		233.81	50.36	175.58	49.40	224.98	768.00	79.39	1356.54
Energy Intensity (kW.h/sqm)		65.00	14.00	48.81	13.73	62.54	213.50	22.07	377.12
Electric Share		1.00	1.00	1.00	1.00		0.11	0.14	
Electricity Subtotal (GW.h)		89.05	19.18	66.87	18.82	85.69	32.18	4.23	230.32
Heat Pump Share			0.00				0.03	0.04	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				1.83	0.30	2.13
Total Electricity (GW.h)		89.05	19.18	66.87	18.82	85.69	34.00	4.54	232.45
Universities	4.7								
Energy Intensity (MJ/sqm)		233.81	50.36	113.53	55.01	168.53	768.00	79.39	1300.10
Energy Intensity (kW.h/sqm)		65.00	14.00	31.56	15.29	46.85	213.50	22.07	361.43
Electric Share		1.00	1.00	1.00	1.00		0.11	0.14	
Electricity Subtotal (GW.h)		307.45	66.22	149.28	72.33	221.61	111.09	14.61	720.98
Heat Pump Share			0.00				0.03	0.04	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				7.57	1.04	8.62
Total Electricity (GW.h)		307.45	66.22	149.28	72.33	221.61	118.66	15.66	729.60
EDUCATION	21.3								
Energy Intensity (MJ/sqm)		174.54	50.36	111.01	32.73	143.74	810.78	51.22	1230.65
Energy Intensity (kW.h/sqm)		48.52	14.00	30.86	9.10	39.96	225.40	14.24	342.12
Electricity Sub-total		1031.56	297.64	656.09	193.45	849.55	427.53	36.55	2642.83
Heat Pump Electricity			0.00				40.00	2.19	0.03
SUBSECTOR ELECTRICITY (GW.H)		1031.56	297.64	656.09	193.45	849.55	467.53	38.74	2685.01
SUBSECTOR ELECTRICITY (PJ)		3.71	1.07	2.36	0.70	3.06	1.68	0.14	9.66
HEALTH	5.1								
Energy Intensity (MJ/sqm)		329.10	131.62	232.32	101.30	333.62	832.48	113.45	1740.27
Energy Intensity (kW.h/sqm)		91.49	36.59	64.58	28.16	92.75	231.43	31.54	483.80
Electric Share		1.00	1.00	1.00	1.00		0.04	0.16	
Electricity Subtotal (GW.h)		468.43	187.34	330.67	144.19	474.86	50.48	25.53	1206.63
Heat Pump Share			0.00				0.00	0.00	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				0.00	0.00	0.00
SUBSECTOR ELECTRICITY (GW.H)		468.43	187.34	330.67	144.19	474.86	50.48	25.53	1206.63
SUBSECTOR ELECTRICITY (PJ)		1.68	0.67	1.19	0.52	1.71	0.18	0.09	4.34

Table 1.3 (continued)
ELECTRICITY USE IN 1989 VINTAGE COMM
COMMERCIAL BUILDING STOCK IN 2000
FROZEN EFFICIENCY FORECAST

BUILDING TYPE	FLOOR AREA (sqm(10e6))	LIGHTING	COOLING	AUXILIARY			SPACE	WATER	TOTAL
				Motors	Equip	Total Auxiliary			
RELIGIOUS	3.4								
Energy Intensity (MJ/sqm)		186.26	22.01	102.77	0.00	102.77	546.76	90.00	947.81
Energy Intensity (kW.h/sqm)		51.78	6.12	28.57	0.00	28.57	152.00	25.02	
Electric Share		1.00	1.00	1.00	1.00		0.02	0.11	
Electricity Subtotal (GW.h)		177.09	20.93	97.71	0.00	97.71	10.40	9.63	315.75
Heat Pump Share			0.00				0.01	0.00	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				0.86	0.00	0.86
SUBSECTOR ELECTRICITY (GW.H)		177.09	20.93	97.71	0.00	97.71	11.25	9.63	316.61
SUBSECTOR ELECTRICITY (PJ)		0.64	0.08	0.35	0.00	0.35	0.04	0.03	1.14
OTHER INSTIT.	11.7								
Energy Intensity (MJ/sqm)		179.86	130.00	287.77	0.00	287.77	700.00	160.00	1457.63
Energy Intensity (kW.h/sqm)		50.00	36.14	80.00	0.00	80.00	194.60	44.48	
Electric Share		1.00	1.00	1.00	1.00		0.06	0.14	
Electricity Subtotal (GW.h)		586.00	423.56	937.60	0.00	937.60	136.84	72.98	2156.99
Heat Pump Share			0.00				0.02	0.03	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				13.57	3.51	17.08
SUBSECTOR ELECTRICITY (GW.H)		586.00	423.56	937.60	0.00	937.60	150.41	76.49	2174.06
SUBSECTOR ELECTRICITY (PJ)		2.11	1.52	3.37	0.00	3.37	0.54	0.28	7.82
Small Office	14.2								
Energy Intensity (MJ/sqm)		371.70	141.37	287.25	81.33	368.58	749.21	39.89	1670.75
Energy Intensity (kW.h/sqm)		103.33	39.30	79.86	22.61	102.47	208.28	11.09	
Electric Share		1.00	1.00	1.00	1.00		0.14	0.17	
Electricity Subtotal (GW.h)		1465.25	557.27	1132.36	320.61	1452.97	413.48	26.73	3915.70
Heat Pump Share			0.00				0.04	0.04	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				28.80	1.42	30.21
Total Electricity (GW.h)		1465.25	557.27	1132.36	320.61	1452.97	442.27	28.15	3945.91
Large Office	16.0								
Energy Intensity (MJ/sqm)		557.57	141.37	406.55	81.33	487.88	749.21	39.89	1975.92
Energy Intensity (kW.h/sqm)		155.00	39.30	113.02	22.61	135.63	208.28	11.09	
Electric Share		1.00	1.00	1.00	1.00		0.14	0.17	
Electricity Subtotal (GW.h)		2478.51	628.41	1807.22	361.53	2168.76	466.26	30.15	5772.08
Heat Pump Share			0.00				0.04	0.04	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				32.47	1.60	34.07
Total Electricity (GW.h)		2478.51	628.41	1807.22	361.53	2168.76	498.73	31.74	5806.15
TOTAL OFFICE	30.2								
Energy Intensity (MJ/sqm)		470.21	141.37	350.48	81.33	431.81	749.21	39.89	1832.49
Energy Intensity (kW.h/sqm)		130.72	39.30	97.43	22.61	120.04	208.28	11.09	
Electricity Sub-total		3943.76	1185.68	2939.58	682.14	3621.72	879.73	56.88	9687.78
Heat Pump Electricity			0.00				61.27	3.01	
SUBSECTOR ELECTRICITY (GW.H)		3943.76	1185.68	2939.58	682.14	3621.72	941.00	59.89	9752.06
SUBSECTOR ELECTRICITY (PJ)		14.19	4.27	10.57	2.45	13.03	3.38	0.22	34.85

Table I.3 (continued)
ELECTRICITY USE IN 1989 VINTAGE COMMERCIAL BUILDING STOCK IN 2000
FROZEN EFFICIENCY FORECAST

BUILDING TYPE	FLOOR AREA (sqm(10e6))	LIGHTING	COOLING	AUXILIARY Motors	AUXILIARY Equip	AUXILIARY Total Auxiliary	SPACE	WATER	TOTAL
Small Retail	3.5								
Energy Intensity (MJ/sqm)		696.94	140.94	278.78	126.60	405.38	464.64	100.00	1807.90
Energy Intensity (kW.h/sqm)		193.75	39.18	77.50	35.20	112.70	129.17	27.80	502.60
Electric Share		1.00	1.00	1.00	1.00		0.09	0.19	
Electricity Subtotal (GW.h)		682.00	137.91	272.80	123.89	396.69	40.92	18.48	1276.00
Heat Pump Share			0.00				0.02	0.02	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				2.27	0.49	2.76
Total Electricity (GW.h)		682.00	137.91	272.80	123.89	396.69	43.19	18.96	1278.76
Large Retail	16.0								
Energy Intensity (MJ/sqm)		503.35	140.94	247.81	126.60	374.41	464.64	100.00	1583.33
Energy Intensity (kW.h/sqm)		139.93	39.18	68.89	35.20	104.09	129.17	27.80	
Electric Share		1.00	1.00	1.00	1.00		0.09	0.19	
Electricity Subtotal (GW.h)		2240.28	627.27	1102.93	563.49	1666.42	186.12	84.03	4804.12
Heat Pump Share			0.00				0.02	0.02	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				10.34	2.23	12.57
Total Electricity (GW.h)		2240.28	627.27	1102.93	563.49	1666.42	196.46	86.26	4816.69
Food Stores	5.0								
Energy Intensity (MJ/sqm)		503.35	140.94	1391.19	126.60	1517.79	464.64	192.01	2818.73
Energy Intensity (kW.h/sqm)		139.93	39.18	386.75	35.20	421.95	129.17	53.38	
Electric Share		1.00	1.00	1.00	1.00		0.09	0.19	
Electricity Subtotal (GW.h)		703.85	197.08	1945.35	177.04	2122.39	58.48	50.69	3132.48
Heat Pump Share			0.00				0.02	0.02	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				3.25	1.34	4.59
Total Electricity (GW.h)		703.85	197.08	1945.35	177.04	2122.39	61.72	52.04	3137.07
STORES	24.6								
Energy Intensity (MJ/sqm)		531.09	140.94	486.41	126.60	613.02	464.64	118.84	1868.53
Energy Intensity (kW.h/sqm)		147.64	39.18	135.22	35.20	170.42	129.17	33.04	
Electricity Sub-total		3626.13	962.26	3321.08	864.42	4185.50	285.52	153.20	9212.60
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	15.86	4.06	19.92
SUBSECTOR ELECTRICITY (GW.H)		3626.13	962.26	3321.08	864.42	4185.50	301.38	157.26	9232.52
SUBSECTOR ELECTRICITY (PJ)		13.04	3.46	11.95	3.11	15.06	1.08	0.57	33.21
Motel	0.3								
Energy Intensity (MJ/sqm)		296.87	459.60	808.45	440.53	1248.98	539.57	179.86	2724.88
Energy Intensity (kW.h/sqm)		82.53	127.77	224.75	122.47	347.22	150.00	50.00	
Electric Share		1.00	1.00	1.00	1.00		0.40	0.40	
Electricity Subtotal (GW.h)		25.58	39.61	69.67	37.97	107.64	18.60	6.20	197.63
Heat Pump Share			0.00				0.10	0.10	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				1.16	0.39	1.55
Total Electricity (GW.h)		25.58	39.61	69.67	37.97	107.64	19.76	6.59	199.18
Hotel	2.9								
Energy Intensity (MJ/sqm)		348.49	459.60	997.03	305.93	1302.96	700.00	160.00	2971.05
Energy Intensity (kW.h/sqm)		96.88	127.77	277.18	85.05	362.22	194.60	44.48	
Electric Share		1.00	1.00	1.00	1.00		0.07	0.19	
Electricity Subtotal (GW.h)		279.01	367.98	798.26	244.94	1043.20	41.64	24.48	1756.31
Heat Pump Share			0.00				0.00	0.00	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				0.00	0.00	0.00
Total Electricity (GW.h)		279.01	367.98	798.26	244.94	1043.20	41.64	24.48	1756.31

Table I.3 (continued)
ELECTRICITY USE IN 1989 VINTAGE COMMERCIAL BUILDING STOCK IN 2000
FROZEN EFFICIENCY FORECAST

BUILDING TYPE	FLOOR AREA (sqm(10e6))	LIGHTING	COOLING	AUXILIARY			SPACE	WATER	TOTAL
				Motors	Equip	Total Auxiliary			
Restaurant	3.9								
Energy Intensity (MJ/sqm)		490.00	459.60	175.54	1526.00	1701.54	700.00	420.00	3771.14
Energy Intensity (kW.h/sqm)		136.22	127.77	48.80	424.23	473.03	194.60	116.76	
Electric Share		1.00	1.00	1.00	0.10		0.07	0.19	
Electricity Subtotal (GW.h)		533.98	500.86	191.30	166.30	357.59	56.68	87.47	1536.58
Heat Pump Share			0.00				0.00	0.00	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				0.00	0.00	0.00
Total Electricity (GW.h)		533.98	500.86	191.30	166.30	357.59	56.68	87.47	1536.58
HOTELS/REST.	7.1								
Energy Intensity (MJ/sqm)		424.26	459.60	535.89	984.47	1520.36	693.01	304.21	3401.44
Energy Intensity (kW.h/sqm)		117.94	127.77	148.98	273.68	422.66	192.66	84.57	
Electricity Sub-total		838.58	908.44	1059.23	449.20	1508.43	116.92	118.15	3490.52
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	1.16	0.39	1.55
SUBSECTOR ELECTRICITY (GW.H)		838.58	908.44	1059.23	449.20	1508.43	118.08	118.53	3492.07
SUBSECTOR ELECTRICITY (PJ)		3.02	3.27	3.81	1.62	5.43	0.42	0.43	12.56
RECREATION	4.2								
Energy Intensity (MJ/sqm)		303.56	23.99	499.50	0.00	499.50	658.27	85.00	1570.32
Energy Intensity (kW.h/sqm)		84.39	6.67	138.86	0.00	138.86	183.00	23.63	
Electric Share		1.00	1.00	1.00	1.00		0.11	0.22	
Electricity Subtotal (GW.h)		357.81	28.28	588.77	0.00	588.77	85.35	22.04	1082.25
Heat Pump Share			0.00				0.02	0.05	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				3.88	1.16	5.04
SUBSECTOR ELECTRICITY (GW.H)		357.81	28.28	588.77	0.00	588.77	89.23	23.21	1087.30
SUBSECTOR ELECTRICITY (PJ)		1.29	0.10	2.12	0.00	2.12	0.32	0.08	3.91
WAREHOUSE	20.1								
Energy Intensity (MJ/sqm)		245.50	27.99	216.04	0.00	216.04	431.65	4.24	925.43
Energy Intensity (kW.h/sqm)		68.25	7.78	60.06	0.00	60.06	120.00	1.18	
Electric Share		1.00	1.00	1.00	1.00		0.04	0.09	
Electricity Subtotal (GW.h)		1370.46	156.22	1206.00	0.00	1206.00	87.71	2.13	2822.52
Heat Pump Share			0.00				0.00	0.00	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				0.00	0.00	0.00
SUBSECTOR ELECTRICITY (GW.H)		1370.46	156.22	1206.00	0.00	1206.00	87.71	2.13	2822.52
SUBSECTOR ELECTRICITY (PJ)		4.93	0.56	4.34	0.00	4.34	0.32	0.01	10.15
TOTALS	127.7								
Heat Pump (GW.h)		0.00	0.00	0.00	0.00	0.00	136.60	14.31	150.91
Heat Pump (PJ)		0.00	0.00	0.00	0.00	0.00	0.49	0.05	0.54
Other Electricity (GW.h)		12399.82	4170.36	11136.74	2333.40	13470.13	2080.48	497.09	32617.88
Other Electricity (PJ)		44.60	15.00	40.06	8.39	48.45	7.48	1.79	117.33
TOTAL ELECTRICITY (GW.H)		12399.82	4170.36	11136.74	2333.40	13470.13	2217.08	511.40	32768.79
TOTAL ELECTRICITY (PJ)		44.60	15.00	40.06	8.39	48.45	7.98	1.84	117.87

Table I.4
ELECTRICITY USE IN 1990-2000 COMMERCIAL BUILDING STOCK IN 2000
FROZEN EFFICIENCY FORECAST

BUILDING TYPE	FLOOR AREA (sqm(10e6))	LIGHTING	COOLING	AUXILIARY			SPACE	WATER	TOTAL
				Motors	Equip	Total Auxiliary			
Elementary School	2.7								
Energy Intensity (MJ/sqm)		115.18	53.38	96.80	21.09	117.89	690.00	39.89	1016.34
Energy Intensity (kW.h/sqm)		32.02	14.84	26.91	5.86	32.77	191.82	11.09	282.54
Electric Share		1.00	1.00	1.00	1.00		0.24	0.24	
Electricity Subtotal (GW.h)		86.77	40.22	72.93	15.89	88.82	124.76	7.21	347.78
Heat Pump Share			0.00				0.04	0.06	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				5.39	0.45	5.84
Total Electricity (GW.h)		86.77	40.22	72.93	15.89	88.82	130.15	7.66	353.62
Secondary School	1.2								
Energy Intensity (MJ/sqm)		157.98	53.38	121.98	31.64	153.62	690.00	36.01	1090.99
Energy Intensity (kW.h/sqm)		43.92	14.84	33.91	8.80	42.71	191.82	10.01	303.30
Electric Share		1.00	1.00	1.00	1.00		0.24	0.24	
Electricity Subtotal (GW.h)		51.39	17.36	39.67	10.29	49.97	53.86	2.81	175.39
Heat Pump Share			0.00				0.04	0.06	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				2.33	0.18	2.50
Total Electricity (GW.h)		51.39	17.36	39.67	10.29	49.97	56.19	2.99	177.89
Colleges	0.4								
Energy Intensity (MJ/sqm)		198.74	53.38	175.58	49.40	224.98	640.00	36.01	1153.11
Energy Intensity (kW.h/sqm)		55.25	14.84	48.81	13.73	62.54	177.92	10.01	320.56
Electric Share		1.00	1.00	1.00	1.00		0.24	0.24	
Electricity Subtotal (GW.h)		19.34	5.19	17.08	4.81	21.89	14.95	0.84	62.21
Heat Pump Share			0.00				0.03	0.06	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				0.50	0.05	0.55
Total Electricity (GW.h)		19.34	5.19	17.08	4.81	21.89	15.45	0.89	62.76
Universities	1.2								
Energy Intensity (MJ/sqm)		198.74	53.38	113.53	55.01	168.53	640.00	36.01	1096.66
Energy Intensity (kW.h/sqm)		55.25	14.84	31.56	15.29	46.85	177.92	10.01	304.87
Electric Share		1.00	1.00	1.00	1.00		0.24	0.24	
Electricity Subtotal (GW.h)		66.85	17.96	38.19	18.50	56.69	51.67	2.91	196.08
Heat Pump Share			0.00				0.03	0.06	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				1.73	0.18	1.91
Total Electricity (GW.h)		66.85	17.96	38.19	18.50	56.69	53.40	3.09	197.99
EDUCATION	5.4								
Energy Intensity (MJ/sqm)		148.35	53.38	111.00	32.73	143.73	675.66	37.94	1059.06
Energy Intensity (kW.h/sqm)		41.24	14.84	30.86	9.10	39.96	187.83	10.55	294.42
Electricity Sub-total		224.35	80.73	167.87	49.49	217.37	255.19	14.63	792.27
Heat Pump Electricity			0.00				9.96	0.86	0.01
SUBSECTOR ELECTRICITY (GW.H)		224.35	80.73	167.87	49.49	217.37	265.15	15.49	803.09
SUBSECTOR ELECTRICITY (PJ)		0.81	0.29	0.60	0.18	0.78	0.95	0.06	2.89

Continued.....

Table 1.4 (continued)
ELECTRICITY USE IN 1990-2000 COMMERCIAL BUILDING STOCK IN 2000
FROZEN EFFICIENCY FORECAST

BUILDING TYPE	FLOOR AREA (sqm(10e6))	LIGHTING	COOLING	AUXILIARY			SPACE	WATER	TOTAL
				Motors	Equip	Total Auxiliary			
HEALTH	2.2								
Energy Intensity (MJ/sqm)		279.74	139.52	232.32	101.30	333.62	700.00	113.45	1566.32
Energy Intensity (kW.h/sqm)		77.77	38.79	64.58	28.16	92.75	194.60	31.54	435.44
Electric Share		1.00	1.00	1.00	1.00		0.08	0.15	
Electricity Subtotal (GW.h)		171.86	85.72	142.73	62.24	204.97	34.41	10.46	507.41
Heat Pump Share			0.00				0.02	0.05	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				2.15	0.87	3.02
SUBSECTOR ELECTRICITY (GW.H)		171.86	85.72	142.73	62.24	204.97	36.56	11.33	510.43
SUBSECTOR ELECTRICITY (PJ)		0.62	0.31	0.51	0.22	0.74	0.13	0.04	1.84
RELIGIOUS	1.3								
Energy Intensity (MJ/sqm)		158.32	23.34	102.77	0.00	102.77	546.76	90.00	921.19
Energy Intensity (kW.h/sqm)		44.01	6.49	28.57	0.00	28.57	152.00	25.02	
Electric Share		1.00	1.00	1.00	1.00		0.09	0.12	
Electricity Subtotal (GW.h)		58.98	8.69	38.28	0.00	38.28	18.33	4.02	128.31
Heat Pump Share			0.00				0.03	0.03	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				1.61	0.25	1.86
SUBSECTOR ELECTRICITY (GW.H)		58.98	8.69	38.28	0.00	38.28	19.94	4.27	130.17
SUBSECTOR ELECTRICITY (PJ)		0.21	0.03	0.14	0.00	0.14	0.07	0.02	0.47
OTHER INSTIT.	7.1								
Energy Intensity (MJ/sqm)		152.88	137.80	287.77	0.00	287.77	700.00	160.00	1438.45
Energy Intensity (kW.h/sqm)		42.50	38.31	80.00	0.00	80.00	194.60	44.48	
Electric Share		1.00	1.00	1.00	1.00		0.09	0.17	
Electricity Subtotal (GW.h)		302.18	272.37	568.80	0.00	568.80	124.52	53.76	1321.64
Heat Pump Share			0.00				0.03	0.06	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				11.59	4.53	16.12
SUBSECTOR ELECTRICITY (GW.H)		302.18	272.37	568.80	0.00	568.80	136.11	58.29	1337.75
SUBSECTOR ELECTRICITY (PJ)		1.09	0.98	2.05	0.00	2.05	0.49	0.21	4.81
Small Office	9.2								
Energy Intensity (MJ/sqm)		315.94	149.85	287.25	81.33	368.58	749.21	39.89	1623.47
Energy Intensity (kW.h/sqm)		87.83	41.66	79.86	22.61	102.47	208.28	11.09	
Electric Share		1.00	1.00	1.00	1.00		0.28	0.30	
Electricity Subtotal (GW.h)		811.55	384.92	737.87	208.92	946.79	538.86	30.74	2712.86
Heat Pump Share			0.00				0.11	0.12	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				51.91	3.05	54.96
Total Electricity (GW.h)		811.55	384.92	737.87	208.92	946.79	590.78	33.79	2767.83
Large Office	10.4								
Energy Intensity (MJ/sqm)		473.92	148.82	406.55	81.33	487.88	749.21	39.89	1899.73
Energy Intensity (kW.h/sqm)		131.75	41.37	113.02	22.61	135.63	208.28	11.09	
Electric Share		1.00	1.00	1.00	1.00		0.28	0.30	
Electricity Subtotal (GW.h)		1371.52	430.68	1176.56	235.37	1411.93	607.09	34.63	3855.86
Heat Pump Share			0.00				0.11	0.12	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				58.49	3.43	61.92
Total Electricity (GW.h)		1371.52	430.68	1176.56	235.37	1411.93	665.58	38.07	3917.78

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Table I.4 (continued)
ELECTRICITY USE IN 1990-2000 COMMERCIAL BUILDING STOCK IN 2000
FROZEN EFFICIENCY FORECAST

BUILDING TYPE	FLOOR AREA (sqm(10e6))	LIGHTING	COOLING	AUXILIARY			SPACE	WATER	TOTAL
				Motors	Equip	Total Auxiliary			
TOTAL OFFICE	19.7								
Energy Intensity (MJ/sqm)		399.63	149.30	350.45	81.33	431.79	749.21	39.89	1769.82
Energy Intensity (kW.h/sqm)		111.10	41.51	97.43	22.61	120.04	208.28	11.09	
Electricity Sub-total		2183.07	815.60	1914.43	444.29	2358.71	1145.96	65.38	6568.72
Heat Pump Electricity			0.00				110.40	6.48	
SUBSECTOR ELECTRICITY (GW.H)		2183.07	815.60	1914.43	444.29	2358.71	1256.36	71.86	6685.60
SUBSECTOR ELECTRICITY (PJ)		7.85	2.93	6.89	1.60	8.48	4.52	0.26	23.63
Small Retail	2.3								
Energy Intensity (MJ/sqm)		592.40	166.30	278.78	126.60	405.38	464.64	100.00	1728.73
Energy Intensity (kW.h/sqm)		164.69	46.23	77.50	35.20	112.70	129.17	27.80	480.59
Electric Share		1.00	1.00	1.00	1.00		0.22	0.19	
Electricity Subtotal (GW.h)		373.84	104.95	175.93	79.90	255.82	64.51	11.99	811.11
Heat Pump Share			0.00				0.05	0.06	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				3.78	0.95	4.73
Total Electricity (GW.h)		373.84	104.95	175.93	79.90	255.82	68.29	12.94	815.84
Large Retail	10.3								
Energy Intensity (MJ/sqm)		427.84	149.39	247.81	126.60	374.41	464.64	100.00	1516.29
Energy Intensity (kW.h/sqm)		118.94	41.53	68.89	35.20	104.09	129.17	27.80	
Electric Share		1.00	1.00	1.00	1.00		0.22	0.19	
Electricity Subtotal (GW.h)		1226.28	428.18	710.26	362.87	1073.13	292.98	54.46	3075.03
Heat Pump Share			0.00				0.05	0.06	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				17.18	4.30	21.48
Total Electricity (GW.h)		1226.28	428.18	710.26	362.87	1073.13	310.16	58.76	3096.51
Food Stores	3.2								
Energy Intensity (MJ/sqm)		427.84	149.39	1391.19	126.60	1517.79	464.64	192.01	2751.68
Energy Intensity (kW.h/sqm)		118.94	41.53	386.75	35.20	421.95	129.17	53.38	
Electric Share		1.00	1.00	1.00	1.00		0.22	0.19	
Electricity Subtotal (GW.h)		385.37	134.56	1253.07	114.04	1367.11	92.07	32.86	2011.97
Heat Pump Share			0.00				0.05	0.06	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				5.40	2.59	7.99
Total Electricity (GW.h)		385.37	134.56	1253.07	114.04	1367.11	97.47	35.45	2019.96
STORES	15.8								
Energy Intensity (MJ/sqm)		451.46	151.82	486.42	126.60	613.02	464.64	118.84	1799.78
Energy Intensity (kW.h/sqm)		125.50	42.21	135.22	35.20	170.42	129.17	33.04	
Electricity Sub-total		1985.48	667.69	2139.25	556.80	2696.05	449.56	99.31	5898.10
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	26.36	7.84	34.20
SUBSECTOR ELECTRICITY (GW.H)		1985.48	667.69	2139.25	556.80	2696.05	475.92	107.15	5932.30
SUBSECTOR ELECTRICITY (PJ)		7.14	2.40	7.70	2.00	9.70	1.71	0.39	21.34
Motel	0.2								
Energy Intensity (MJ/sqm)		252.34	487.18	808.45	440.53	1248.98	539.57	179.86	2707.92
Energy Intensity (kW.h/sqm)		70.15	135.44	224.75	122.47	347.22	150.00	50.00	
Electric Share		1.00	1.00	1.00	1.00		0.40	0.40	
Electricity Subtotal (GW.h)		13.33	25.73	42.70	23.27	65.97	11.40	3.80	120.23
Heat Pump Share			0.00				0.15	0.10	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				1.07	0.24	1.31
Total Electricity (GW.h)		13.33	25.73	42.70	23.27	65.97	12.47	4.04	121.54

Table I.4 (continued)
ELECTRICITY USE IN 1990-2000 COMMERCIAL BUILDING STOCK IN 2000
FROZEN EFFICIENCY FORECAST

BUILDING TYPE	FLOOR AREA (sqm(10e6))	LIGHTING	COOLING	AUXILIARY			SPACE	WATER	TOTAL
				Motors	Equip	Total Auxiliary			
Hotel	1.7								
Energy Intensity (MJ/sqm)		296.22	487.18	997.03	280.67	1277.70	700.00	160.00	2921.09
Energy Intensity (kW.h/sqm)		82.35	135.44	277.18	78.03	355.20	194.60	44.48	
Electric Share		1.00	1.00	1.00	1.00		0.17	0.17	
Electricity Subtotal (GW.h)		143.29	235.66	482.28	135.76	618.05	57.56	12.77	1067.33
Heat Pump Share			0.00				0.04	0.04	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				3.06	0.68	3.74
Total Electricity (GW.h)		143.29	235.66	482.28	135.76	618.05	60.63	13.45	1071.07
Restaurant	2.4								
Energy Intensity (MJ/sqm)		416.50	487.18	175.54	1526.00	1701.54	700.00	420.00	3725.22
Energy Intensity (kW.h/sqm)		115.79	135.44	48.80	424.23	473.03	194.60	116.76	
Electric Share		1.00	1.00	1.00	0.10		0.17	0.17	
Electricity Subtotal (GW.h)		274.42	320.98	115.66	100.54	216.20	78.40	45.66	935.66
Heat Pump Share			0.00				0.04	0.04	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				4.17	2.42	6.60
Total Electricity (GW.h)		274.42	320.98	115.66	100.54	216.20	82.58	48.08	942.26
HOTELS/REST.	4.3								
Energy Intensity (MJ/sqm)		360.57	487.18	535.92	974.11	1510.03	692.91	304.18	3354.88
Energy Intensity (kW.h/sqm)		100.24	135.44	148.99	270.80	419.79	192.63	84.56	
Electricity Sub-total		431.03	582.38	640.64	259.57	900.22	147.37	62.23	2123.22
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	8.31	3.34	11.64
SUBSECTOR ELECTRICITY (GW.H)		431.03	582.38	640.64	259.57	900.22	155.67	65.57	2134.86
SUBSECTOR ELECTRICITY (PJ)		1.55	2.09	2.30	0.93	3.24	0.56	0.24	7.68
RECREATION	2.5								
Energy Intensity (MJ/sqm)		258.03	25.43	499.50	0.00	499.50	658.27	85.00	1526.23
Energy Intensity (kW.h/sqm)		71.73	7.07	138.86	0.00	138.86	183.00	23.63	
Electric Share		1.00	1.00	1.00	1.00		0.10	0.21	
Electricity Subtotal (GW.h)		182.20	17.96	352.70	0.00	352.70	46.48	12.60	611.95
Heat Pump Share			0.00				0.04	0.06	
Heat Pump COP			3.00				4.00	4.00	
Heat Pump Electricity			0.00				4.07	0.93	4.99
SUBSECTOR ELECTRICITY (GW.H)		182.20	17.96	352.70	0.00	352.70	50.55	13.53	616.94
SUBSECTOR ELECTRICITY (PJ)		0.66	0.06	1.27	0.00	1.27	0.18	0.05	2.22
WAREHOUSE	9.2								
Energy Intensity (MJ/sqm)		208.7	29.7	216.0	0.0	216.0	359.7	4.2	818.34
Energy Intensity (kW.h/sqm)		58.01	8.25	60.06	0.00	60.06	100.00	1.18	
Electric Share		1.0	1.0	1.0	1.0		0.1	0.1	
Electricity Subtotal (GW.h)		532.0	75.6	550.8	0.0	550.8	91.7	1.5	1251.56
Heat Pump Share			0.0				0.0	0.0	
Heat Pump COP			3.0				4.0	4.0	
Heat Pump Electricity			0.0				9.2	0.1	9.25
SUBSECTOR ELECTRICITY (GW.H)		532.0	75.6	550.8	0.0	550.8	100.9	1.6	1260.81
SUBSECTOR ELECTRICITY (PJ)		1.9	0.3	2.0	0.0	2.0	0.4	0.0	4.54
TOTALS	67.6								
Heat Pump (GW.h)		0.0	0.0	0.0	0.0	0.0	183.6	25.2	208.79
Heat Pump (PJ)		0.0	0.0	0.0	0.0	0.0	0.7	0.1	0.75
Other Electricity (GW.h)		6071.1	2606.8	6515.5	1372.4	7887.9	2313.5	323.9	19203.17
Other Electricity (PJ)		21.8	9.4	23.4	4.9	28.4	8.3	1.2	69.08
TOTAL ELECTRICITY (GW.H)		6071.1	2606.8	6515.5	1372.4	7887.9	2497.1	349.1	19411.96
TOTAL ELECTRICITY (PJ)		21.8	9.4	23.4	4.9	28.4	9.0	1.3	69.83

Table I.5
TOTAL COMMERCIAL BUILDINGS ELECTRICITY USE IN ONTARIO IN 2000
FROZEN EFFICIENCY FORECAST

BUILDING TYPE	FLOOR AREA (sqm(10e6))	LIGHTING	COOLING	AUXILIARY			SPACE	WATER	TOTAL
				Motors	Equip	Total Auxiliary			
Elementary School	13.30								
Energy Intensity (MJ/sqm)		131.36	50.98	96.80	21.09	117.89	799.88	39.89	1140.00
Energy Intensity (kW.h/sqm)		36.52	14.17	26.91	5.86	32.77	222.37	11.09	316.92
Electricity Subtotal (GW.h)		485.70	188.48	357.90	77.99	435.90	295.40	18.05	1423.52
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	17.58	1.04	18.62
Total Electricity (GW.h)		485.70	188.48	357.90	77.99	435.90	312.98	19.09	1442.14
Secondary School	5.74								
Energy Intensity (MJ/sqm)		180.18	50.98	121.98	31.64	153.62	799.87	39.10	1223.75
Energy Intensity (kW.h/sqm)		50.09	14.17	33.91	8.80	42.71	222.36	10.87	340.20
Electricity Subtotal (GW.h)		287.52	81.34	194.64	50.49	245.13	127.50	7.49	748.98
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	20.74	0.43	21.17
Total Electricity (GW.h)		287.52	81.34	194.64	50.49	245.13	148.24	7.92	770.15
Colleges	1.72								
Energy Intensity (MJ/sqm)		226.68	50.97	175.58	49.40	224.98	741.95	70.56	1315.14
Energy Intensity (kW.h/sqm)		63.02	14.17	48.81	13.73	62.54	206.26	19.62	365.61
Electricity Subtotal (GW.h)		108.39	24.37	83.95	23.62	107.58	47.12	5.07	292.53
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	2.33	0.35	2.68
Total Electricity (GW.h)		108.39	24.37	83.95	23.62	107.58	49.45	5.43	295.22
Universities	5.94								
Energy Intensity (MJ/sqm)		226.67	50.98	113.53	55.01	168.53	741.93	70.55	1258.66
Energy Intensity (kW.h/sqm)		63.01	14.17	31.56	15.29	46.85	206.26	19.61	349.91
Electricity Subtotal (GW.h)		374.30	84.18	187.47	90.84	278.31	162.75	17.52	917.06
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	9.31	1.23	10.53
Total Electricity (GW.h)		374.30	84.18	187.47	90.84	278.31	172.06	18.75	927.59
EDUCATION	26.70								
Energy Intensity (MJ/sqm)		169.20	50.98	111.01	32.73	143.74	783.25	48.52	1195.69
Energy Intensity (kW.h/sqm)		47.04	14.17	30.86	9.10	39.96	217.74	13.49	332.40
Electricity Sub-total		1255.91	378.37	823.97	242.95	1066.91	682.72	51.18	3435.10
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	49.96	3.05	0.05
SUBSECTOR ELECTRICITY (GW.H)		1255.91	378.37	823.97	242.95	1066.91	732.68	54.23	3488.10
SUBSECTOR ELECTRICITY (PJ)		4.52	1.36	2.96	0.87	3.84	2.64	0.20	12.55
HEALTH	7.33								
Energy Intensity (MJ/sqm)		314.22	134.00	232.32	101.30	333.62	792.54	113.45	1687.82
Energy Intensity (kW.h/sqm)		87.35	37.25	64.58	28.16	92.75	220.33	31.54	469.22
Electricity Subtotal (GW.h)		640.29	273.06	473.40	206.42	679.82	84.88	35.99	1714.04
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	2.15	0.87	3.02
SUBSECTOR ELECTRICITY (GW.H)		640.29	273.06	473.40	206.42	679.82	87.03	36.86	1717.06
SUBSECTOR ELECTRICITY (PJ)		2.30	0.98	1.70	0.74	2.45	0.31	0.13	6.18
RELIGIOUS	4.76								
Energy Intensity (MJ/sqm)		178.39	22.39	102.77	0.00	102.77	546.76	90.00	940.31
Energy Intensity (kW.h/sqm)		49.59	6.22	28.57	0.00	28.57	152.00	25.02	
Electricity Subtotal (GW.h)		236.07	29.62	135.99	0.00	135.99	28.73	13.65	444.06
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	2.47	0.25	2.72
SUBSECTOR ELECTRICITY (GW.H)		236.07	29.62	135.99	0.00	135.99	31.19	13.90	446.78
SUBSECTOR ELECTRICITY (PJ)		0.85	0.11	0.49	0.00	0.49	0.11	0.05	1.61

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Table 1.5 (continued)
TOTAL COMMERCIAL BUILDINGS ELECTRICITY USE IN ONTARIO IN 2000
FROZEN EFFICIENCY FORECAST

BUILDING TYPE	FLOOR AREA (sqm(10e6))	LIGHTING	COOLING	AUXILIARY			SPACE	WATER	TOTAL
				Motors	Equip	Total Auxiliary			
OTHER INSTIT.	18.83								
Energy Intensity (MJ/sqm)		169.67	132.95	287.77	0.00	287.77	700.00	160.00	1450.38
Energy Intensity (kW.h/sqm)		47.17	36.96	80.00	0.00	80.00	194.60	44.48	
Electricity Subtotal (GW.h)		888.18	695.93	1506.40	0.00	1506.40	261.37	126.75	3478.62
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	25.16	8.04	33.19
SUBSECTOR ELECTRICITY (GW.H)		888.18	695.93	1506.40	0.00	1506.40	286.53	134.78	3511.82
SUBSECTOR ELECTRICITY (PJ)		3.19	2.50	5.42	0.00	5.42	1.03	0.48	12.63
Small Office	23.42								
Energy Intensity (MJ/sqm)		349.70	144.71	287.25	81.33	368.58	749.21	39.89	1652.10
Energy Intensity (kW.h/sqm)		97.22	40.23	79.86	22.61	102.47	208.28	11.09	
Electricity Subtotal (GW.h)		2276.80	942.19	1870.23	529.53	2399.75	952.34	57.48	6628.56
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	80.71	4.46	85.17
Total Electricity (GW.h)		2276.80	942.19	1870.23	529.53	2399.75	1033.05	61.94	6713.74
Large Office	26.40								
Energy Intensity (MJ/sqm)		524.58	144.31	406.55	81.33	487.88	749.21	39.89	1945.88
Energy Intensity (kW.h/sqm)		145.83	40.12	113.02	22.61	135.63	208.28	11.09	
Electricity Subtotal (GW.h)		3850.03	1059.09	2983.78	596.90	3580.68	1073.35	64.78	9627.93
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	90.96	5.03	95.99
Total Electricity (GW.h)		3850.03	1059.09	2983.78	596.90	3580.68	1164.31	69.81	9723.92
TOTAL OFFICE	49.82								
Energy Intensity (MJ/sqm)		442.37	144.50	350.47	81.33	431.80	749.21	39.89	1807.77
Energy Intensity (kW.h/sqm)		122.98	40.17	97.43	22.61	120.04	208.28	11.09	
Electricity Sub-total		6126.83	2001.28	4854.01	1126.43	5980.44	2025.69	122.26	16256.50
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	171.67	9.49	
SUBSECTOR ELECTRICITY (GW.H)		6126.83	2001.28	4854.01	1126.43	5980.44	2197.36	131.75	16437.66
SUBSECTOR ELECTRICITY (PJ)		22.04	7.20	17.46	4.05	21.51	7.90	0.47	58.48
Small Retail	5.79								
Energy Intensity (MJ/sqm)		655.96	150.88	278.78	126.60	405.38	464.64	100.00	1776.86
Energy Intensity (kW.h/sqm)		182.36	41.94	77.50	35.20	112.70	129.17	27.80	493.97
Electricity Subtotal (GW.h)		1055.84	242.86	448.73	203.79	652.51	105.43	30.47	2087.11
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	6.06	1.44	7.49
Total Electricity (GW.h)		1055.84	242.86	448.73	203.79	652.51	111.48	31.90	2094.60
Large Retail	26.32								
Energy Intensity (MJ/sqm)		473.77	144.25	247.81	126.60	374.41	464.64	100.00	1557.07
Energy Intensity (kW.h/sqm)		131.71	40.10	68.89	35.20	104.09	129.17	27.80	
Electricity Subtotal (GW.h)		3466.56	1055.45	1813.18	926.36	2739.55	479.10	138.49	7879.15
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	27.52	6.52	34.04
Total Electricity (GW.h)		3466.56	1055.45	1813.18	926.36	2739.55	506.62	145.01	7913.19
Food Stores	8.27								
Energy Intensity (MJ/sqm)		473.77	144.25	1391.19	126.60	1517.79	464.64	192.01	2792.46
Energy Intensity (kW.h/sqm)		131.71	40.10	386.75	35.20	421.95	129.17	53.38	
Electricity Subtotal (GW.h)		1089.22	331.64	3198.42	291.07	3489.49	150.55	83.55	5144.45
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	8.65	3.94	12.58
Total Electricity (GW.h)		1089.22	331.64	3198.42	291.07	3489.49	159.20	87.49	5157.03
STORES	40.38								
Energy Intensity (MJ/sqm)		499.89	145.20	486.42	126.60	613.02	464.64	118.84	1841.60
Energy Intensity (kW.h/sqm)		138.97	40.37	135.22	35.20	170.42	129.17	33.04	
Electricity Sub-total		5611.61	1629.95	5460.33	1421.22	6881.55	735.08	252.51	15110.70
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	42.22	11.90	54.12
SUBSECTOR ELECTRICITY (GW.H)		5611.61	1629.95	5460.33	1421.22	6881.55	777.30	264.40	15164.82
SUBSECTOR ELECTRICITY (PJ)		20.19	5.86	19.64	5.11	24.75	2.80	0.95	54.55

Table I.5 (continued)
TOTAL COMMERCIAL BUILDINGS ELECTRICITY USE IN ONTARIO IN 2000
FROZEN EFFICIENCY FORECAST

BUILDING TYPE	FLOOR AREA (sqm(10e6))	LIGHTING	COOLING	AUXILIARY			SPACE	WATER	TOTAL
				Motors	Equip	Total Auxiliary			
Motel	0.50								
Energy Intensity (MJ/sqm)		279.95	470.08	808.45	440.53	1248.98	539.57	179.86	2718.44
Energy Intensity (kW.h/sqm)		77.83	130.68	224.75	122.47	347.22	150.00	50.00	
Electricity Subtotal (GW.h)		38.91	65.34	112.37	61.23	173.61	30.00	10.00	317.86
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	2.23	0.63	2.86
Total Electricity (GW.h)		38.91	65.34	112.37	61.23	173.61	32.23	10.63	320.72
Hotel	4.62								
Energy Intensity (MJ/sqm)		328.80	469.99	997.03	296.41	1293.44	700.00	160.00	2952.24
Energy Intensity (kW.h/sqm)		91.41	130.66	277.18	82.40	359.58	194.60	44.48	
Electricity Subtotal (GW.h)		422.30	603.64	1280.55	380.70	1661.25	99.20	37.25	2823.64
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	3.06	0.68	3.74
Total Electricity (GW.h)		422.30	603.64	1280.55	380.70	1661.25	102.27	37.93	2827.38
Restaurant	6.29								
Energy Intensity (MJ/sqm)		462.31	469.99	175.54	1526.00	1701.54	700.00	420.00	3753.84
Energy Intensity (kW.h/sqm)		128.52	130.66	48.80	424.23	473.03	194.60	116.76	
Electricity Subtotal (GW.h)		808.40	821.84	306.95	266.84	573.79	135.08	133.13	2472.24
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	4.17	2.42	6.60
Total Electricity (GW.h)		808.40	821.84	306.95	266.84	573.79	139.26	135.55	2478.83
HOTELS/REST.	11.41								
Energy Intensity (MJ/sqm)		400.26	470.00	535.90	980.56	1516.47	692.97	304.20	3383.89
Energy Intensity (kW.h/sqm)		111.27	130.66	148.98	272.60	421.58	192.65	84.57	
Electricity Sub-total		1269.61	1490.82	1699.87	708.77	2408.65	264.29	180.38	5613.74
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	9.47	3.72	13.19
SUBSECTOR ELECTRICITY (GW.H)		1269.61	1490.82	1699.87	708.77	2408.65	273.76	184.10	5626.93
SUBSECTOR ELECTRICITY (PJ)		4.57	5.36	6.11	2.55	8.66	0.98	0.66	20.24
RECREATION	6.78								
Energy Intensity (MJ/sqm)		286.50	24.53	499.50	0.00	499.50	658.27	85.00	1553.80
Energy Intensity (kW.h/sqm)		79.65	6.82	138.86	0.00	138.86	183.00	23.63	
Electricity Subtotal (GW.h)		540.01	46.24	941.47	0.00	941.47	131.83	34.65	1694.20
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	7.95	2.09	10.04
SUBSECTOR ELECTRICITY (GW.H)		540.01	46.24	941.47	0.00	941.47	139.78	36.74	1704.24
WAREHOUSE	29.25								
Energy Intensity (MJ/sqm)		233.96	28.51	216.04	0.00	216.04	409.10	4.24	891.86
Energy Intensity (kW.h/sqm)		65.04	7.93	60.06	0.00	60.06	113.73	1.18	
Electricity Subtotal (GW.h)		1902.43	231.85	1756.76	0.00	1756.76	179.41	3.64	4074.09
Heat Pump Electricity		0.00	0.00	0.00	0.00	0.00	9.17	0.08	9.25
SUBSECTOR ELECTRICITY (GW.H)		1902.43	231.85	1756.76	0.00	1756.76	188.58	3.72	4083.34
SUBSECTOR ELECTRICITY (PJ)		6.84	0.83	6.32	0.00	6.32	0.68	0.01	14.69
TOTALS	195.26								
Heat Pump (GW.h)		0.00	0.00	0.00	0.00	0.00	320.21	39.49	359.70
Heat Pump (PJ)		0.00	0.00	0.00	0.00	0.00	1.15	0.14	1.29
Other Electricity (GW.h)		18470.94	6777.12	17652.20	3705.79	21357.99	4394.00	820.99	51821.05
Other Electricity (PJ)		66.44	24.38	63.50	13.33	76.83	15.81	2.95	186.41
TOTAL ELECTRICITY (GW.H)		18470.94	6777.12	17652.20	3705.79	21357.99	4714.21	860.49	52180.75
TOTAL ELECTRICITY (PJ)		66.44	24.38	63.50	13.33	76.83	16.96	3.10	187.70

APPENDIX II

DATABASE FOR ECONOMIC ANALYSIS

Appendix II Database for Economic Analysis

Scenario A -- Low Cost
Total Investment: 2375.46
Total Energy Saved in 2000: 16244 Displaced Capacity in 2000: 3783.23

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Acceleration Scenario Rates	0.07	0.07	0.08	0.08	0.09	0.1	0.11	0.12	0.13	0.15	
Cumulative	0.07	0.14	0.22	0.3	0.39	0.49	0.6	0.72	0.85	1	1
Annual Investment (10e6$)	238	238	238	238	238	238	238	238	238	238	
Acceleration Variation (10e6$)	166	166	190	190	214	238	261	285	309	356	
Energy Saved in Year (GW.h)		1624	3249	4873	6498	8122	9746	11371	12995	14620	16244
Acceleration Scenario (GW.h)		1137	2274	3574	4873	6335	7960	9746	11696	13807	16244
Assumed ACF	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Displaced Capacity (MW)		378	378	378	378	378	378	378	378	378	378
Acceleration Scenario (MW)		265	265	303	303	340	378	416	454	492	567
Scenario System Value (1987$/kw)		478	517	559	601	567	717	739	790	845	895
Value at linear (10e3 1987$)		180947	195615	211318	227297	214524	271181	279728	299020	319792	338498
Value at acceleration (10e3 $)		126663	136930	169055	181837	193072	271181	307701	358824	415729	507746
Energy System Value (DOD)		19.6	20.3	20.4	21.9	29.2	36.5	39.9	44.5	46.9	51.1
Deflator	0.840	0.792	0.747	0.705	0.665	0.627	0.592	0.558	0.527	0.497	0.469
Energy System Value (1987 $/MWH)		15.53	15.17	14.38	14.56	18.32	21.60	22.28	23.44	23.31	23.96
Energy Value of Scenario ($10e3)		25219	49282	70082	94636	148799	210564	253341	304634	340752	389168
Accerleration Scenario		17653	34498	51394	70977	116063	171961	217149	274171	321821	389168
Capacity Plus Energy		206166	244897	281401	321932	363323	481745	533069	603654	660543	727666
Acceleration Scenario		144316	171428	220448	252814	309135	443142	524850	632994	737550	896915
								Year 2000 Resid Value			3561260

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Appendix II Database for Economic Analysis

Scenario A -- High Cost

Total Investment: 4819.89

Total Energy Saved in 2000: 15930.8 Displaced Capacity in 2000: 3924.19

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Acceleration Scenario Rates	0.07	0.07	0.08	0.08	0.09	0.1	0.11	0.12	0.13	0.15	
Cumulative	0.07	0.14	0.22	0.3	0.39	0.49	0.6	0.72	0.85	1	1
Annual Investment (10e6$)	482	482	482	482	482	482	482	482	482	482	
Acceleration Variation (10e6$)	337	337	386	386	434	482	530	578	627	723	
Energy Saved in Year (GW.h)		1593	3186	4779	6372	7965	9559	11152	12745	14338	15931
Acceleration Scenario (GW.h)		1115	2230	3505	4779	6213	7806	9559	11470	13541	15931
Assumed ACF	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Displaced Capacity (MW)		392	392	392	392	392	392	392	392	392	392
Acceleration Scenario (MW)		275	275	314	314	353	392	432	471	510	589
Scenario System Value (1987$/kw)		615	656	701	747	753	864	895	949	1006	1056
Value at linear (10e3 1987$)		241263	257475	275244	293105	295484	339025	351044	372254	394779	414575
Value at acceleration (10e3 $)		168884	180233	220195	234484	265935	339025	386148	446705	513212	621862
Energy System Value (DOD)		19.6	20.3	20.4	21.9	29.2	36.5	39.9	44.5	46.9	51.1
Deflator	0.840	0.792	0.747	0.705	0.665	0.627	0.592	0.558	0.527	0.497	0.469
Energy System Value (1987 $/MWH)		15.53	15.17	14.38	14.56	18.32	21.60	22.28	23.44	23.31	23.96
Energy Value of Scenario ($10e3)		24733	48332	68731	92812	145930	206505	248457	298762	334183	381667
Accerleration Scenario		17313	33833	50403	69609	113826	168646	212963	268886	315617	381667
Capacity Plus Energy		265996	305807	343976	385917	441414	545530	599501	671016	728962	796241
Acceleration Scenario		186197	214065	270598	304093	379761	507670	599112	715591	828830	1003529
								Year 2000 Resid Value			2932439

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Appendix II Database for Economic Analysis

Scenario B -- Low Cost
Total Investment: 4567.73
Total Energy Saved in 2000: 21269 Displaced Capacity in 2000: 5537.17

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Acceleration Scenario Rates	0.07	0.07	0.08	0.08	0.09	0.1	0.11	0.12	0.13	0.15	
Cumulative	0.07	0.14	0.22	0.3	0.39	0.49	0.6	0.72	0.85	1	1
Annual Investment (10e6$)	457	457	457	457	457	457	457	457	457	457	
Acceleration Variation (10e6$)	320	320	365	365	411	457	502	548	594	685	
Energy Saved in Year (GW.h)		2127	4254	6381	8508	10635	12761	14888	17015	19142	21269
Acceleration Scenario (GW.h)		1489	2978	4679	6381	8295	10422	12761	15314	18079	21269
Assumed ACF	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Displaced Capacity (MW)		554	554	554	554	554	554	554	554	554	554
Acceleration Scenario (MW)		388	388	443	443	498	554	609	664	720	831
Scenario System Value (1987$/kw)		563	602	644	686	677	797	825	876	929	973
Value at linear (10e3 1987$)		311704	333278	356534	380069	374909	441440	456692	484838	514621	538867
Value at acceleration (10e3 $)		218193	233295	285227	304055	337418	441440	502362	581806	669007	808301
Energy System Value (DOD)		19.6	20.3	20.4	21.9	29.2	36.5	39.9	44.5	46.9	51.1
Deflator	0.840	0.792	0.747	0.705	0.665	0.627	0.592	0.558	0.527	0.497	0.469
Energy System Value (1987 $/MWH)		15.53	15.17	14.38	14.56	18.32	21.60	22.28	23.44	23.31	23.96
Energy Value of Scenario ($10e3)		33020	64527	91762	123911	194829	275701	331711	398871	446161	509556
Accerleration Scenario		23114	45169	67292	92933	151966	225156	284323	358984	421375	509556
Capacity Plus Energy		344724	397806	448296	503980	569737	717141	788403	883709	960782	1048423
Acceleration Scenario		241307	278464	352520	396988	489384	666596	786685	940790	1090382	1317857
								Year 2000 Resid Value			4043078

Appendix II Database for Economic Analysis

Scenario B --- High Cost
Total Investment: 6332.02
Total Energy Saved in 2000: 20928.7 Displaced Capacity in 2000: 5155.31

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Acceleration Scenario Rates	0.07	0.07	0.08	0.08	0.09	0.1	0.11	0.12	0.13	0.15	
Cumulative	0.07	0.14	0.22	0.3	0.39	0.49	0.6	0.72	0.85	1	1
Annual Investment (10e6$)	633	633	633	633	633	633	633	633	633	633	
Acceleration Variation (10e6$)	443	443	507	507	570	633	697	760	823	950	
Energy Saved in Year (GW.h)		2093	4186	6279	8372	10464	12557	14650	16743	18836	20929
Acceleration Scenario (GW.h)		1465	2930	4604	6279	8162	10255	12557	15069	17789	20929
Assumed ACF	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Displaced Capacity (MW)		516	516	516	516	516	516	516	516	516	516
Acceleration Scenario (MW)		361	361	412	412	464	516	567	619	670	773
Scenario System Value (1987$/kw)		580	619	662	705	710	815	844	895	949	997
Value at linear (10e3 1987$)		299013	319106	341128	363264	366212	420175	435071	461359	489274	513809
Value at acceleration (10e3 $)		209309	223374	272902	290611	329591	420175	478578	553630	636057	770713
Energy System Value (DOD)		19.6	20.3	20.4	21.9	29.2	36.5	39.9	44.5	46.9	51.1
Deflator	0.840	0.792	0.747	0.705	0.665	0.627	0.592	0.558	0.527	0.497	0.469
Energy System Value (1987 $/MWH)		15.53	15.17	14.38	14.56	18.32	21.60	22.28	23.44	23.31	23.96
Energy Value of Scenario ($10e3)		32492	63495	90294	121929	191712	271291	326405	392491	439025	501405
Accerleration Scenario		22744	44447	66216	91447	149536	221554	279775	353242	414635	501405
Capacity Plus Energy		331505	382601	431422	485193	557924	691466	761476	853849	928299	1015214
Acceleration Scenario		232054	267820	339118	382058	479126	641729	758353	906872	1050691	1272118
								Year 2000 Resid Value			3656304

Appendix II Database for Economic Analysis

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Scenario C — Low Cost
Total Investment: 6833.04
Total Energy Saved in 2000: 26073 Displaced Capacity in 2000: 6590.70

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Acceleration Scenario Rates	0.07	0.07	0.08	0.08	0.09	0.1	0.11	0.12	0.13	0.15	
Cumulative	0.07	0.14	0.22	0.3	0.39	0.49	0.6	0.72	0.85	1	1
Annual Investment (10e6$)	683	683	683	683	683	683	683	683	683	683	
Acceleration Variation (10e6$)	478	478	547	547	615	683	752	820	888	1025	
Energy Saved in Year (GW.h)		2607	5215	7822	10429	13037	15644	18251	20858	23466	26073
Acceleration Scenario (GW.h)		1825	3650	5736	7822	10168	12776	15644	18773	22162	26073
Assumed ACF	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Displaced Capacity (MW)		659	659	659	659	659	659	659	659	659	659
Acceleration Scenario (MW)		461	461	527	527	593	659	725	791	857	989
Scenario System Value (1987$/kw)		574	613	655	698	697	808	837	888	942	987
Value at linear (10e3 1987$)		378092	403775	431722	459893	459395	532719	551421	584978	620550	650751
Value at acceleration (10e3 $)		264664	282643	345377	367915	413455	532719	606563	701973	806715	976127
Energy System Value (DOD)		19.6	20.3	20.4	21.9	29.2	36.5	39.9	44.5	46.9	51.1
Deflator	0.840	0.792	0.747	0.705	0.665	0.627	0.592	0.558	0.527	0.497	0.469
Energy System Value (1987 $/MWH)		15.53	15.17	14.38	14.56	18.32	21.60	22.28	23.44	23.31	23.96
Energy Value of Scenario ($10e3)		40478	79102	112488	151899	238834	337973	406634	488964	546935	624648
Accerleration Scenario		28335	55371	82491	113924	186291	276011	348543	440067	516550	624648
Capacity Plus Energy		418570	482877	544210	611792	698229	870693	958055	1073941	1167485	1275400
Acceleration Scenario		292999	338014	427869	481839	599746	808731	955106	1142040	1323265	1600775
								Year 2000 Resid Value			5008590

Appendix II Database for Economic Analysis

Scenario C -- High Cost
Total Investment: 7844.14
Total Energy Saved in 2000: 25926.7 Displaced Capacity in 2000: 6386.43

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Acceleration Scenario Rates	0.07	0.07	0.08	0.08	0.09	0.1	0.11	0.12	0.13	0.15	
Cumulative	0.07	0.14	0.22	0.3	0.39	0.49	0.6	0.72	0.85	1	1
Annual Investment (10e6$)	784	784	784	784	784	784	784	784	784	784	
Acceleration Variation (10e6$)	549	549	628	628	706	784	863	941	1020	1177	
Energy Saved in Year (GW.h)		2593	5185	7778	10371	12963	15556	18149	20741	23334	25927
Acceleration Scenario (GW.h)		1815	3630	5704	7778	10111	12704	15556	18667	22038	25927
Assumed ACF	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Displaced Capacity (MW)		639	639	639	639	639	639	639	639	639	639
Acceleration Scenario (MW)		447	447	511	511	575	639	703	766	830	958
Scenario System Value (1987$/kw)		580	619	662	705	710	815	844	895	949	997
Value at linear (10e3 1987$)		370419	395310	422591	450013	453666	520515	538968	571534	606116	636509
Value at acceleration (10e3 $)		259293	276717	338073	360011	408299	520515	592865	685841	787951	954764
Energy System Value (DOD)		19.6	20.3	20.4	21.9	29.2	36.5	39.9	44.5	46.9	51.1
Deflator	0.840	0.792	0.747	0.705	0 665	0.627	0.592	0.558	0.527	0.497	0.469
Energy System Value (1987 $/MWH)		15.53	15.17	14.38	14.56	18.32	21.60	22.28	23.44	23.31	23.96
Energy Value of Scenario ($10e3)		40251	78658	111857	151046	237494	336077	404352	486220	543867	621144
Accerleration Scenario		28176	55061	82029	113285	185246	274463	346588	437598	513652	621144
Capacity Plus Energy		410670	473968	534448	601060	691160	856592	943321	1057754	1149983	1257653
Acceleration Scenario		287469	331778	420101	473295	593545	794978	939453	123439	1301603	1575908
								Year 2000 Resid Value			4807357

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APPENDIX III

EXCERPTS FROM

ELECTRICITY CONSERVATION SUPPLY CURVES FOR ONTARIO

August, 1987

ELECTRICITY CONSERVATION
Supply Curves for Ontario

Prepared for the
Ontario Ministry of Energy
By

Marbek Resource Consultants

Ontario
Ministry of Energy
Robert C. Wong
Minister

Marbek

ELECTRICITY CONSERVATION SUPPLY CURVES FOR ONTARIO

Final Report

Prepared by:
Marbek Resource Consultants

Prepared for:
Ontario Ministry of Energy

August 1987

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2. CONSERVATION SUPPLY CURVES

The concept of the conservation supply curve derives from an end-use orientation to the analysis of fuel and electricity supply and demand. The starting point of this approach is the recognition that demands for fuels and electricity are derived from more fundamental demands for energy services. To identify the most cost-effective way of providing the energy end-use services in an economy, techniques and technologies that can reduce the fuel or electricity required for a particular end-use service must be compared on a symmetrical basis with fuel and electricity supply options. The "conservation supply curve" is a conceptual tool for making such symmetrical comparisons. It is partly analogous to the conventional economic supply curve.

The notion of a supply curve comes from economic theory. It expresses the instantaneous relationship between the price of a given commodity and the amount of the commodity that will be delivered at each price. Even in theory, it is a relatively sophisticated concept (for example, what is the "commodity" and to what point is it delivered).

Despite these theoretical and practical difficulties, the concept of a supply curve is so useful that, under rather less restrictive assumptions, it became common in the 1960's to extend the idea to relationships between price (or cost) and sets of opportunities to produce minerals and energy. Still later, the importance of conservation became clearer in the sense of an alternative way to deliver a specific end-use service. There turned out to be little difference between producing an added unit of some commodity and adjusting the end-use technology in such a way that that unit was no longer necessary. The term "supply price" came to be used equally for additions to energy supply and options for energy conservation supply curves that are the subject of this analysis.

There are three types of information required to construct any conservation supply curve -- the baseline energy use (against which the savings are measured), the energy savings that can be achieved by a particular measure, and the cost of the measure.

Baseline Energy Use

Because the conservation "supply" is actually the difference between the energy use if the measure were not implemented and the energy use after the measure is implemented, it is very important to have accurate baseline energy end use data. This presents a particular problem in the construction of

conservation supply curves for future years, since any baseline will of necessity be arbitrary.

Energy Savings

Equally important as the accuracy of the baseline data is an accurate calculation of the amount of energy that will be saved by the implementation of a particular measure. This knowledge is usually based on experience and on mathematical models (for example, building energy models). Models are especially important if several measures are being considered on one curve, because the baseline energy use will change after each measure, and this in turn will affect the savings that can be achieved with subsequent measures.

Cost of Measures

The conservation supply curve is most versatile when the costs of the conserved energy can be presented as independent of the costs of supply. This implies a rejection of such indicators as payback, internal rate of return, net present value and benefit/cost ratios, as they all require some assumption about future energy prices. Two indicators are considered here, one related to payback calculations and the other to life cycle costing.

The unit cost of the conservation energy can be calculated simply by spreading the costs over the savings achieved in the first "n" years. The selection of "n" will depend on the purposes for which the curve is being produced. An individual looking for a payback of three years or less would choose n=3 to calculate the unit cost of the conserved energy. The physical lifetime of the measure could also be used to determine a lower limit of the unit cost using this method.

A more sophisticated method, and one better suited to policy analysis, is to calculate the life cycle cost of the measure, or the cost of conserved energy (CCE) [Meier, 1982]. This calculation divides the discounted value of the initial investment (plus annual O&M charges where applicable) by the annual energy savings. The formula is simply:

$$CCE = (I/E) \quad [d/1-(1+d)^{-n}]$$

where I is the initial investment
E is the annual saving in energy (compared to baseline)
d is the discount rate
n is the life time of the measure (in years)

The equation illustrates the relative importance of various of the input data, including the energy savings (E), the cost of the measure (I), the discount rate (d) and the lifetime (n). The elasticities of the CCE are as follows [Meier, 1982]:

With respect to investment I: +1

With respect to energy savings E: -1

With respect to amortization time n: $(n \ln(1+d))/(1-(1+d)^{-n})$

With respect to discount rate d: $1 + ([nd]/[(1+d)^{n+1}-(1+d)])$

The CCE is particularly sensitive to the choice of discount rate, especially in the 1 to 5% range typically chosen for constant dollar discount rates.

Interactive Effects

As mentioned above, the baseline against which energy savings are measured is affected by all other measures previously implemented, and this is the root of the interactive effects which constitute the most difficult methodological problem in the construction of conservation supply curves. Measures typically save some percentage of the baseline energy use, and so the absolute savings they achieve change (usually downward) in proportion to the amount of energy saved by all the previous measures. This in turn affects the unit cost of the measure (which is inversely proportional to the absolute value of E).

An example is provided by Meier [1982], who developed an algorithm for calculating the CCE for a sequence of space heating conservation measures for a house. First, the CCE of each of the eight measures is calculated as if it were the first to be implemented. Then the lowest cost measure (duct insulation in this case) is implemented, the baseline energy is recalculated and the unit costs of the remaining measures are recalculated and re-ordered. The iteration continues until the optimum order is identified. However, if the initial cost of the duct insulation is increased until it is slightly more expensive than the next cheapest measure (wall insulation), its ultimate position in the order falls not to second but to fourth because of the interactive effects on other measures of insulating the walls first.

Commercial lighting conservation measures provide another example of these interactive effects. Reductions in the energy output of lights reduce the cooling requirements in commercial buildings in the summer and increase the heating

requirements in the winter. Thus, lighting efficiency improvements also save air conditioning energy but, if implemented first, increase the unit costs of air conditioning efficiency improvements, and conversely for heating energy.

These interactive effects illustrate another important limitation of conservation supply curves that are based on the cost of the conserved energy. The implementation of one measure can send the unit cost of a similar measure skyrocketing. For example, measured against a common baseline, insulating an attic to level A may save electricity at 2¢/kW.h, and insulating it to level B may save more electricity at a slightly higher unit cost. But because of the high labour component of this measure, if the attic is insulated to level A, the unit cost of insulating to level B, given the new baseline, will increase greatly. Thus to avoid double counting, a unit cost value must be selected to provide a basis for choosing between similar and mutually exclusive (for practical purposes) options. A supply curve of electricity conservation available up to, say, five cents per kilowatt-hour will be quite different from one that goes up to three cents per kilowatt-hour, even in the low cost range.

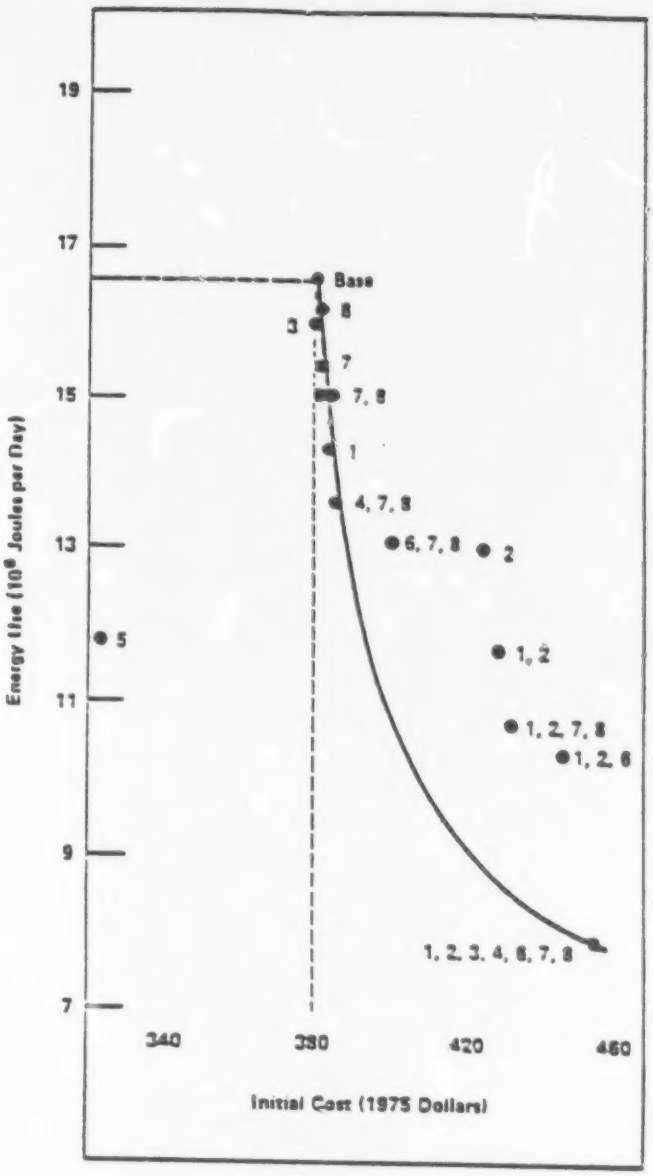
Micro Conservation Supply Curves

The simplest and most well-defined conservation supply curve is that for a single unit end-use device or process. For example, Figure 1 is a supply curve designed to show collections of technical changes that could save electricity in a large, modern refrigerator, and how their costs compared with the resulting savings. It is also a relatively simple task to construct a conservation supply curve for a single building or industrial plant. For example, Figure 2 shows a gas conservation supply curve for a particular single-family dwelling. At this micro level, conservation supply curves can be determined with great accuracy and are the stock-in-trade of the energy services industry in recommending conservation investment schedules for their clients. The precision of these micro supply curves is a direct result of the precision of the data that is possible at this level and of the detailed knowledge of the individual building or end use device that can be brought to bear.

Macro Conservation Supply Curves

A "macro conservation supply curve" describes the total conservation potential for many units, and "multiple end-use, macro conservation supply curves", aggregated for an entire sector of the economy are the most complex of all. The

complexity derives from the large variations in the energy use, costs and effects of particular measures from one application to the next. The analyst must rely on average base line energy use, average costs for measures, average effects of the measures, and, most difficult, average interactive effects. As Meier points out, "a kind of uncertainty principle applies here. The more precisely one specifies a conservation measure (to more accurately know its energy savings), the less precisely one knows the stock to which the measure applies". Until much larger statistical energy end-use and conservation data bases are available (that would allow application of techniques such as Monte Carlo to the aggregation problem), the development of macro conservation supply curves will require the heroic assumption that distributions are normal about the averages, and that the data allow one to make a reasonable approximation of the average.



KEY

1	Increase insulation thickness	5	Eliminate frost-free and forced air systems
2	Improve insulation thermal conductivity	6	Improve compressor efficiency
3	Remove fan from cooled area	7	Increase condenser surface area
4	Add anti-sweat heater switch	8	Increase evaporator surface area

*Refrigerator is 18 cu ft and incorporates the options shown in the key.

FIGURE ONE

DAILY ENERGY USE (OR INTENSITY) COMPARED TO THE INITIAL COST OF A TYPICAL TOP-FREEZER REFRIGERATOR*

Source: Hoskins and Hirst, Oak Ridge National Lab Report CON-6 (1977).

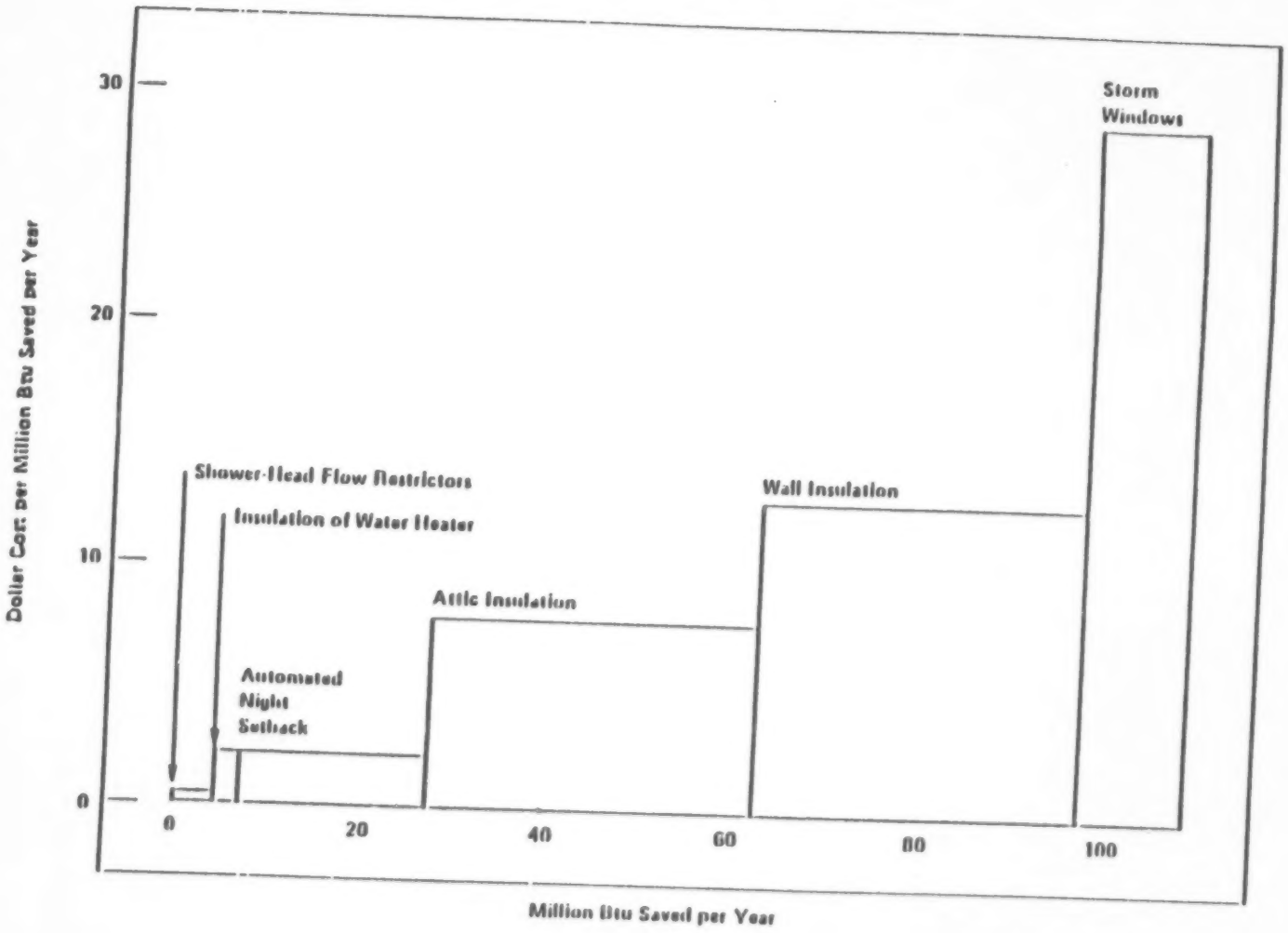


FIGURE TWO

SAVINGS FROM HOT WATER CONSERVATION

In Terms of Gas Conserved in a 1,400-sq ft Uninsulated Single-Family Dwelling

Source: Rosenfeld, Lawrence Berkeley Lab Report 5926 (1977).

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3. APPROACH AND METHOD FOR THIS STUDY

The objective of this study was to create multi-end-use macro supply curves (sometimes called "grand supply curves") for electricity conservation for residential, commercial and industrial sectors in Ontario, as well as a composite curve showing the combined conservation potential in all three sectors.

Given the complexity and enormity of the task, a number of simplifying constraints were agreed to at the outset and at a workshop on the method held during the course of the analysis.

First, the analysis is performed for the conservation of electrical energy, and not for peak capacity. Second, the analysis focuses on the maximum physical conservation potential. No judgements or analysis are presented on rates of penetration, or on the effect of factors other than technical potential that might limit application. Neither is there any analysis of the conservation potential beyond the base year, which was selected to be 1985.

Regarding data sources, the analysis relied on existing end use energy data, engineering and cost studies of conservation potential. Even so, a great deal of recalculation of costs and energy savings was required.

One implication of these constraints is that the calculations are representative, but not comprehensive. A selection of measures were analyzed, but there are almost certainly others which are cheaper and/or would yield greater savings that are not included here. In particular, there is certainly a large remaining potential for "low cost/no cost" conservation in the base year electricity use, but we have not included these measures because it is impossible (given the energy data base) to know how much has already been implemented. For all these reasons, the curves are <u>preliminary</u>.

For the cost calculations, the formula described above for the discounted unit cost was applied. As agreed at a methods workshop held early during the course of the study, a uniform discount rate of 4% was used to allow comparison with electricity supply cost calculations that are performed using this rate. Amortization periods were set according to the expected lifetimes of each technology.

In the case of similar but effectively mutually exclusive measures, a cost of $0.05/kW.h was used as a reference point. Alternative measures were generally selected on the basis of

which could supply the most conservation at a cost below the reference point.

For each sector, the starting point was 1985 electricity consumption, disaggregated by sub-sector and by end use. Electricity conservation measures and technologies were then identified and their potential to reduce the electricity use in each cell of the sector's end use by sub-sector matrix were analyzed. Unit costs of the saved energy were calculated using the formula for the cost of conserved energy described above. The results were then aggregated across sub-sectors by technology/measure to allow a sector wide assessment of the electricity conservation achievable at different cost levels.

5. CONCLUSIONS

5.1 The conservation "supply curve" is a useful tool for visually presenting the costs and potential magnitude of electricity conservation in the society, but care must exercised in interpreting the results, and especially in comparing them with conventional supply curves. Conservation, or electricity productivity improvement, is a much more complex and disaggregate entity than, say, the supply of power plants. For example, we had set out to develop the curves based on conservation measures, but realized during the analysis that the unit cost of a particular measure can vary greatly from one building type to another. Essentially, conservation supply curves show the levelized unit cost of saving electrical energy. The correct figures to compare them with would be the levelized cost of supplying electricity and the life cycle costs of switching to other fuels (where feasible).

5.2 Given the broad qualifications in 5.1, it remains the case that the curves do show a very significant economic potential for electricity conservation and are graphic illustrations of the failure of the market to allocate resources efficiently. The potential for savings are spread throughout the economy, but there are some cells in the end use - subsector - measure space that are particularly rich in potential.

Total evident potential for the measures studied in this report that would be cost effective at 5 ¢/kW.h or less amounts to 26,000 Gw.h, or nearly 25% of the electrical consumption in Ontario in the base year (1985). Of this total, roughly 42% was found in the commercial sector, 23% in the industrial sector, and 35% in the residential sector.

5.3 Because of the extent of detail available on the commercial sector, the savings are more widely distributed than in other sectors, and the curve is smoother than for the other sectors, more truly representing the nature of conservation opportunities. The bulk of the savings come either from improvements in lighting systems or the efficiency and use patterns of motors. The lowest cost blocks are dominated by large office and retail buildings, mostly from simple changes in fluorescent lighting and improved motors. For blocks that represent the use of special measures, subsectors that otherwise show relatively small savings can rise to prominence. For example, hotels and restaurants dominate the savings from the use of compact fluorescents, and the food retail subsector from efficient refrigeration. Utilization

factors and building characteristics are very important determinants of the unit cost of lighting measures.

5.4 Only six general measures were investigated in the industrial sector. Each offered savings in the range of 200 to 2000 GW.h. Costs range from less than 1¢/kW.h to 3.5¢/kw.h. Nearly 40% of the savings can be achieved at costs of less than 0.5¢/kW.h through process controls, instrumentation and waste heat recovery. Lighting, which is responsible for such large savings in the commercial sector, also offers 30% of the savings in the industrial sector; another 30% comes from energy efficient and variable speed motors.

5.5 The bulk of the savings for the residential sector are found to be cost effective below 3 ¢/kW.h, which suggests that it would be worth investigating additional measures in the 3¢/kW.h to 5¢/kW.h range beyond those described here. Of the total 9000 GW.h of savings, nearly half (47%) come from improvements in the efficiency of two appliances, refrigerators and freezers, at a cost of 2 to 2.5 ¢/kW.h. The techniques are well known and already on the market. The next largest share of savings (27%) comes from improvements in electric water heating, all of which are available at costs under 1 ¢/kW.h. The remaining savings are rather widely distributed over various ways to reduce infiltration, add insulation and improve lighting efficiency.

5.6 The savings identified here are incomplete. As emphasized above, this potential represents a selection of technologies, the more important technologies to be sure, but certainly well below the full potential for conservation. Also, as defined, this potential incorporates only those technologies applicable to retrofitting existing systems; new buildings, plant and equipment, and housing could be built to still more efficient levels at the same or lower levels of cost effectiveness.

5.7 Further work related to the conservation supply curves for Ontario should proceed in several directions, but should not necessarily be designed to "refine" the curves presented in this report. In our opinion, macro conservation supply curves are best seen as general indicators, and as a technique for suggesting directions for conservation policy. We also recommend against the use of conservation supply curves for determining the level of conservation potential in future years. Efforts to calculate conservation supply curves for future years require very difficult estimates about what the

baseline consumption will be in future years and, to the extent it is lower than the present, how much of the reduction is due to the conservation measures being analyzed for the curve.

5.8 It would be worthwhile to compare these curves with others that have been prepared for Ontario or for other jurisdictions to see whether important blocks seem to have been omitted or whether the cost or volume of savings for specific blocks seems to be out of line. For example, most of the curves developed by Lovins incorporate substantial savings at negative marginal cost; it would be useful to know whether the absence of such sectors in our results is due to the greater conservatism in our analysis or the neglect of important opportunities. Exactly the same comment applies in areas such as industrial electricity conservation where some analysts have found savings to be much lower than identified here.

5.9 Given the potential identified here, it is relevant to ask how much of that potential is likely to be realized under existing market and institutional conditions over the next five and ten years. In this way, the basic design of and extent of the need for a conservation program will be identified.

5.10 It would be instructive to develop curves for the conservation of peak power requirements. We have not applied load factors to the measures but it would be a relatively straightforward task to do so. There would be other measures that would be interesting to include on such a "power conservation" curve -- in particular, load management and peak flattening techniques.

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APPENDIX IV

ONTARIO HYDRO INCREMENTAL SYSTEM VALUES FOR POWER AND ENERGY

March, 1989

Provision of Energy Prediction 7.2.7

Incremental System Values of Power and Energy

1.0 SCOPE

This prediction of Incremental System Values of Power (Δ kW) and Energy (Δ kW.h) supersedes the previous prediction 7.2.7, dated September 1987. This set of values is provisional until the Demand/Supply Plan is issued.

There are three sets of data issued by various parts of the Corporation that deal with incremental values of power and energy. An Application Guideline, prepared by the Comptroller's Division, describes the three sets: when they can be used, underlying assumptions and their limitations. The guideline is part of the Corporate Financial Evaluation Manual, Chapter 12-03-00.

The incremental system values in this prediction apply for studies of changes at any point on the bulk electricity system between the high voltage terminals of generating stations and the high voltage buses of regional transformer stations. (See Section 6(e).)

For example it may be used for studies of:

- transmission losses or other changes in load on the bulk power system;
- transformation losses at regional transformer stations; and
- small differences in generation from existing hydraulic stations.

For evaluations of changes at any point within the subtransmission system, the primary distribution system or the secondary distribution system, please refer to the above mentioned guideline.

When values are used to evaluate system costs/benefits and impacts due to demand-side/marketing activities and non-utility generation, Demand/Supply Integration Department should be consulted to ensure that the assumptions used in developing these values are compatible with the evaluation being conducted. Values based on different system assumptions, eg. without uncommitted generation, demand management, or non-utility generation are available.

There are other limitations on the use of incremental values and those are discussed later in this document in Section 5.0.

2.0 INCREMENTAL SYSTEM VALUES OF POWER

The incremental system values of power (Δ kW) are shown in Table 1.

The values in Table 1 are for changes in demand that occur during the bulk system winter peak load period. They are expressed in dollars per kilowatt discounted to January 1 of the starting year. In addition, values are also given for changes starting in a particular year and lasting for a number of years. For example, the present worth in 1990 of 1 kW of loss, which will exist from 1990 to 2009 inclusive (20 years), is $691.

The Δ kW values consist of one or more of the following three components:

- The capacity-related part of OM&A costs of fossil-fired stations.
- The full lifecycle costs of providing new capacity resources.
- The effects (savings) of adding new resources on the energy production costs of the existing and planned system.

The Δ kW values developed are based on the 1989 Business Plan assumptions up to the year 2000. Beyond 2000, a representative mix of new resources is used.Existing and committed resources will be adequate until the mid to late 1990s. Then other demand/supply options are required to meet the needs up to the year 2000. These options include demand management, hydraulic and non-utility generation. The costs shown in Table 1 reflect the capacity-related annual OM&A cost of typical fossil generation up to 1999. Starting in 2000, the Δ kW figures reflect the full lifecyle net costs for a representative mix of new resources. The net costs take into account energy production cost savings.

3.0 INCREMENTAL SYSTEM VALUES OF ENERGY

Incremental System Values of Energy (Δ kW.h) are shown in Table 2. They are expressed in mills/kW.h of the year.

Δ kW.h values are calculated by first determining the proportions of incremental generation sources (such as coal, oil and uranium) projected for different years. These proportions are then multiplied by the value of the energy generated from these sources to arrive at the incremental energy values.

The costs of various acid gas emission control measures are included as part of the cost of coal-generated electricity.

In regard to the nuclear energy value, it is assumed that in the long term a fraction of the nuclear energy that is in excess of primary demand can be marketed for a price in excess of its incremental production cost. The fraction marketable depends on the amount of excess. It is smaller when there is more excess nuclear energy available.

The Δ kW.h values recognize that the marketing of excess nuclear energy may be limited by transmission constraints in the short term.

4.0 COMPARISON WITH LAST ISSUE

A comparison of the combined Δ kW and Δ kW.h values of this year with those of the last issue is shown in Figures 1, 2 and 3, for 30%, 70% and 90% annual capacity factor (ACF) respectively. The 70% represents approximately the average ACF of the system.

COMBINED INCREMENTAL VALUES OF ENERGY & POWER

FIGURE 1

30% ANNUAL CAPACITY FACTOR

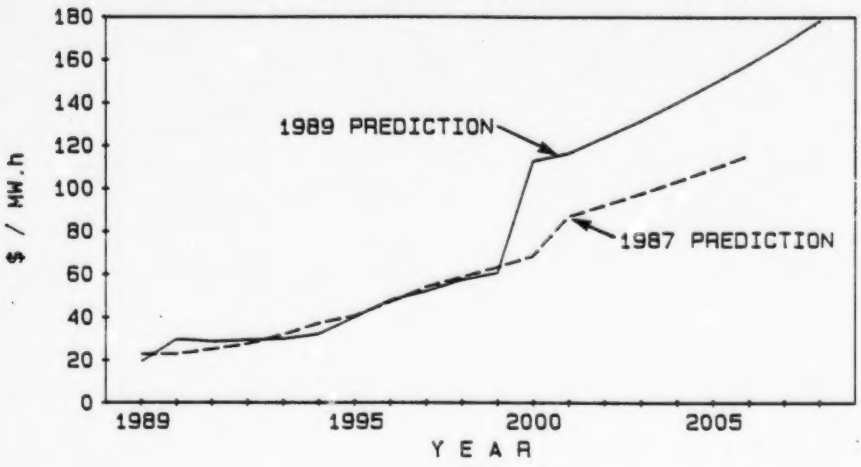


FIGURE 2

70% ANNUAL CAPACITY FACTOR

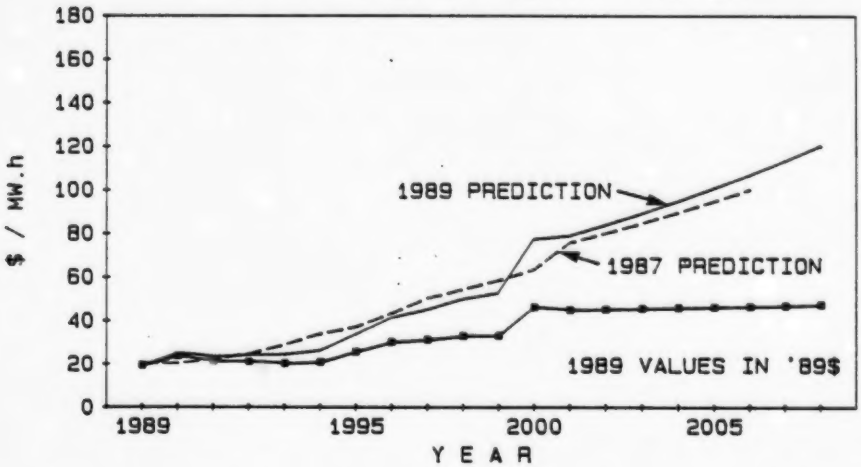
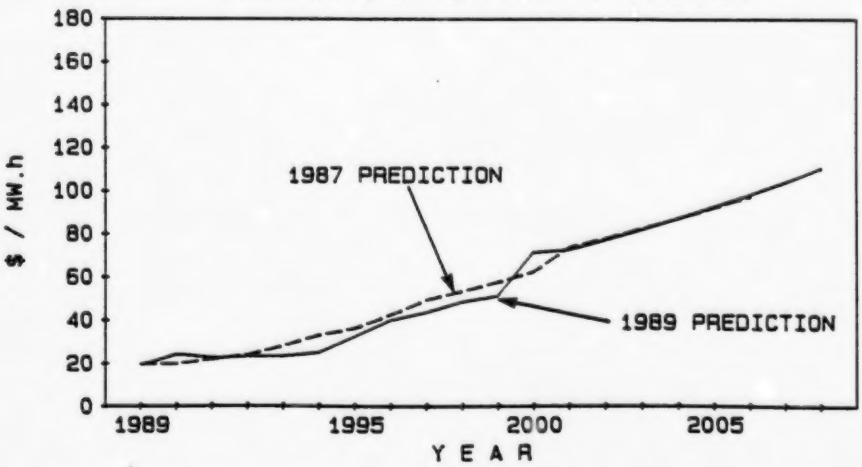


FIGURE 3

90% ANNUAL CAPACITY FACTOR



In combining the Δ kW values with the Δ kW.h values, it is implicitly assumed that a 1 kW change in load will add to or subtract from the system annual peak. The incremental cost of a load that does not contribute to system peak is lower.

From 1989 to 1999 the combined values are lower than those projected in the last issue and higher beyond the year 1999 (see Figure 2). In the period up to 2000, the change between forecasts is dominated by the change in projected fuel prices. For the period to 2010, nuclear fuel prices are about 1-30% lower than the last forecast. Coal prices are expected to be 2-20% lower than in the last forecast. On the other hand, oil prices are expected to be 3-14% higher than last forecast. The total effect of the fuel price changes lowers the combined incremental values in this forecast when compared to the previous issue.

In the period from 2000 onward, the combined incremental values exceed those in the previous forecast. Countering the influence of the lower fuel prices is the increased estimate in the cost of new generation. Estimates for the cost of new nuclear generation were raised in the 1988 review of nuclear costs. A recent review of the costs of new fossil generation has also resulted in an increase from previous estimates.

5.0 LIMITATIONS ON THE USE OF THE VALUES TABULATED

a) The values in Tables 1 and 2 are sensitive to variations in planning assumptions such as forecasts of load growth, escalation and discount rates. As these tabulated values are sensitive to load growth, they should not be used for analysis of scenarios where the load growth is significantly different from the 1988 Long Term Load Forecast (No. 881212).

b) If differences of more than 50 MW are to be evaluated in the East System or 10 MW in the West System, Demand/Supply Integration Department should be consulted. Updates to this prediction will be issued as planning assumptions change.

c) The values are not suited for evaluation of changes in equipment reliability. Different estimates are provided for analysis of changes in incapability factors of existing and new thermal generation, and for changes in power and energy capability insofar as these affect the study, design, and specification of new thermal generation or the modifications of existing thermal generation. Demand/Supply Integration Department provides this information separately.

d) The incremental power values are those that result from peak reductions or additions for a 16-hour period during the day for most of the winter and summer days. This consideration should be borne in mind when these values are used to evaluate the benefits of load management, cogeneration and other demand-side options.

6.0 DATA SOURCES AND ASSUMPTIONS

(a) The Incremental System Values are based on the 1989 System Planning Business Plan and other data. The major data and their sources are as follows:

Division	Dept.	Data
Comptroller	--	. Corporate Financial Discount Rate* (88/12/30)
Economics &Forecasts	. Load Forecasts	. Load forecast 1988 Long Term Load Forecast, No. 881212 (88/12/12)
	. Economics	. Cost Escalators (88/9) . GDP Deflators (88/9)
Fuels	. Financial & Business Planning	. Fuel cost forecasts (89/02/16)
Design & Development	. GEM	. Nuclear stn capital . Nuclear stn capital modifications . Coal stn capital . Coal stn capital modifications . Scrubber capital . Scrubber fixed & variable OM&A . Coal stn decommissioning
	. Nuclear Mat'l Management	. Nuclear stn decommissioning
Tech. & Training Services	. Business Admin. (CNSG)	. Nuclear stn D20 inventory . Nuclear stn commissioning . Nuclear stn fixed OM&A (including D20 upkeep)
	. CNT (NSG)	. Capitalized training
Corporate Accounting	. Asset Accounting	. Irradiated fuel disposal
T & HGD	. Thermal Gen. " " "	. Coal stn commissioning . Capitalized training . New coal stn OM&A . Existing coal stn OM&A
System Planning	. Transmission Planning	. Station Incorporation Costs
PSOD	. Resource Utilization	. System Marginal costs (88/4/21)

* The Discount rates have been lowered by .5% post 2010. Refer to memo to Mr. M.P. Rothman and Mr. B.L. Bennett from Mr. E.A. Marriage dated February 17, 1988 (N706.01).

(b) These system values are valid for use in evaluations of increments or decrements to the current generation expansion plan. In particular, these values assume forecasted non-utility generation, demand management and uncommitted hydraulic generation will be in place.

(c) The incremental cost of capacity in the long term is based on the cost of a representative mix of resources. Ontario Hydro has not decided on the type of resources for the long term. For calculation purposes a mix that is 50% nuclear, 25% clean coal, and 25% CTU was assumed. This mix is intended to represent the cost of the mix of future additional base, intermediate and peaking resources.

The base-loaded resources cover the Candu nuclear generation and base hydraulic, and the intermediate and peaking resources cover a range of options such as fossil, hydraulic, demand management, and purchases from non-utility generators.

(d) Summer consists of the months April to September inclusive, and winter the other six months. Peak hours are defined as the hours 7:00 am to 11:00 pm on working weekdays, with the other hours of those days plus weekend and holidays considered off-peak hours. There are approximations made in the derivation of peak vs off-peak differences in the Δ kW.h values and therefore they may be inappropriate for applications that are sensitive to this difference.

(e) To represent incremental operating costs of existing coal stations in the period to the year 1999, the OM&A costs (in $/kW) of Lambton are considered representative. Of the station OM&A costs, 75% is assumed to be capacity-related and the 25% energy-related. Divisional overheads are taken into account.

Capital modification costs are also included and are added to the operating costs. Half of the average annual capital modification expenditure is assumed capacity-related and the other half, energy-related.

(f) Incremental bulk transmission costs are included in the Δ kW values so that the zone of application is from the output of generation stations to the HV side of regional supply transformers. This is a variation from the application guideline set out in ch. 12-03-00 of the Corporate Financial Evaluation manual which says that the zone of application is down to the low voltage side of regional supply transformers.

Since there are locations where it may not be possible to associate a change in transmission with a change in load, we have prepared Δ kW values without bulk transmission costs. They are available upon request.

Transmission losses are not included in the Δ kW/Δ kW.h values because whether the losses should be included depends on individual application. If necessary an approximate figure of 4% can be added to both the Δ kW and Δ kW.h values to account for transmission losses.

(g) Operator training, net commissioning, decommissioning and irradiated fuel management costs are included.

(h) It is assumed that when supplying incremental capacity and energy demand, the acid gas emission control costs are represented by the following measures:

1990-1993	Burning low sulphur coal with about 1% sulphur content
1994 onwards	Scrubbing 2.5% sulphur coal

Scrubber capital and OM&A costs are included in the Δ kW.h values. The scrubber variable costs have been adjusted to take into account the additional scrubbing necessary to maintain the same level of acid gas emission before and after the addition of an energy increment.

(i) The Δ kW and Δ kW.h values represent the cost of short-lead-time actions that are likely to be used to meet load increases (or decreases) from the forecast load in the period from now to around year 2001. An example of these actions is to increase the operation of coal generating stations. In the later period covered by this prediction, they are the costs associated with a package of representative options.

(j) The incremental energy values for 1989-1994 are based on PSOD's Forecast of System Marginal Costs (SMC) which is based on CES 88-4. PSOD's values and System Planning's values for the transition years are slightly adjusted to effect a smoother transition. It is understood that the SMCs have taken into account various short term considerations such as transmission constraints. Questions about these values should be directed to the Operations Planning Department of PSOD.

1989 FINAL KW RUN

TABLE 1

23-FEB-89

PRESENT WORTH OF PEAK DIFFERENCES IN $/KW AT JANUARY 1 OF THE GIVEN STARTING YEAR
THE VALUES SHOWN APPLY FOR A KILOWATT LOSS COMMENCING IN THE STARTING YEAR AND CONTINUING OVER THE LIFE SHOWN

CAPITAL VALUES OF CAPACITY MIX IN $/KW AS OF JAN 1
STARTING YEAR:

LIFE	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	LIFE
1	0	22	24	25	26	28	29	31	33	35	37	163	173	185	196	209	222	236	251	267	1
2	20	44	46	49	52	54	57	61	64	68	184	320	340	362	385	410	436	464	493	521	2
3	39	65	68	72	76	80	84	89	95	201	326	470	500	532	566	602	641	683	724	764	3
4	58	84	89	93	99	104	110	117	215	329	462	615	654	696	740	788	839	892	944	994	4
5	75	103	108	114	121	128	135	226	331	452	592	754	802	853	908	966	1027	1091	1153	1214	5
6	92	121	127	134	142	150	233	330	442	570	718	887	944	1004	1069	1137	1207	1280	1352	1423	6
7	108	138	145	153	162	240	328	431	548	683	838	1015	1080	1150	1223	1299	1378	1460	1542	1623	7
8	123	154	163	171	243	325	419	527	651	792	954	1138	1212	1289	1369	1453	1541	1632	1723	1812	8
9	138	170	179	244	321	408	506	620	749	896	1065	1257	1337	1421	1509	1600	1696	1796	1895	1993	9
10	152	185	245	315	395	487	590	709	844	997	1172	1370	1456	1547	1641	1740	1844	1951	2059	2165	10
11	166	246	309	382	467	563	671	794	935	1093	1274	1478	1570	1667	1768	1874	1984	2100	2215	2329	11
12	228	303	370	447	536	636	748	877	1022	1186	1372	1581	1678	1781	1888	2001	2118	2241	2364	2485	12
13	272	359	429	509	602	707	823	956	1106	1273	1464	1678	1781	1889	2003	2122	2246	2376	2505	2634	13
14	321	412	485	569	666	774	895	1032	1185	1357	1553	1771	1880	1993	2112	2237	2367	2504	2640	2776	14
15	369	464	540	626	727	839	963	1104	1261	1437	1637	1860	1973	2092	2216	2347	2483	2626	2769	2911	15
20	581	691	780	879	995	1121	1259	1415	1589	1782	2000	2244	2378	2519	2666	2822	2984	3154	3325	3495	20
25	751	872	969	1078	1205	1342	1491	1659	1846	2052	2286	2545	2695	2853	3019	3194	3377	3568	3761	3952	25
30	884	1014	1118	1234	1369	1515	1672	1850	2047	2264	2509	2780	2944	3115	3296	3485	3684	3893	4102	4311	30
35	989	1125	1234	1356	1498	1651	1815	2000	2205	2430	2684	2965	3138	3321	3512	3714	3925	4147	4370	4591	35
40	1071	1212	1325	1452	1599	1757	1926	2118	2328	2560	2821	3110	3291	3482	3682	3893	4114	4346	4579	4812	40
45	1135	1280	1397	1527	1678	1840	2014	2210	2425	2662	2929	3223	3410	3608	3815	4033	4262	4502	4744	4984	45
50	1185	1334	1452	1586	1740	1905	2082	2282	2501	2742	3013	3312	3504	3706	3919	4143	4378	4625	4872	5119	50
55	1224	1376	1496	1632	1789	1956	2136	2338	2560	2804	3079	3381	3577	3784	4001	4229	4469	4720	4973	5225	55
60	1255	1408	1531	1668	1827	1996	2178	2382	2607	2853	3130	3436	3635	3845	4065	4297	4540	4795	5052	5308	60

1989 KWH RUN

TABLE 2

SYSTEM VALUES OF INCREMENTAL ENERGY

ESCALATED COSTS IN YEAR SHOWN - MILLS/KW.H

YEAR	H:-	WINTER PEAK (2000)	WINTER OFF-PEAK (2368)	SUMMER PEAK (2032)	SUMMER OFF-PEAK (2360)	WINTER COMPOSITE (4368)	SUMMER COMPOSITE (4392)	ANNUAL PEAK (4032)	ANNUAL OFF-PEAK (4728)	ANNUAL COMPOSITE (8760)
1989		24.8	18.6	19.5	16.0	21.4	17.6	22.1	17.3	19.5
1990		29.0	20.2	21.9	16.6	24.2	19.1	25.4	18.4	21.6
1991		26.5	18.9	21.8	12.7	22.4	16.9	24.1	15.8	19.6
1992		24.8	19.4	23.0	15.2	21.9	18.8	23.9	17.3	20.3
1993		25.4	20.7	23.0	13.7	22.9	18.0	24.2	17.2	20.4
1994		27.9	22.2	24.7	13.9	24.8	18.9	26.3	18.1	21.9
1995		34.2	29.9	31.3	22.5	31.8	26.6	32.7	26.2	29.2
1996		40.4	37.5	37.9	31.1	38.8	34.3	39.2	34.3	36.5
1997		43.9	40.7	40.8	34.8	42.2	37.6	42.3	37.8	39.9
1998		48.2	44.4	45.0	41.1	46.2	42.9	46.6	42.8	44.5
1999		50.7	48.0	47.4	42.2	49.2	44.6	49.0	45.1	46.9
2000		55.2	51.9	51.0	46.8	53.4	48.7	53.1	49.3	51.1
2001		55.5	51.9	50.9	46.8	53.5	48.7	53.2	49.4	51.1
2002		58.7	54.9	53.8	49.5	56.7	51.5	56.3	52.2	54.1
2003		62.5	58.5	57.3	52.7	60.3	54.8	59.9	55.6	57.6
2004		66.4	62.1	60.8	56.0	64.1	58.2	63.6	59.1	61.1
2005		70.5	65.9	64.6	59.4	68.0	61.8	67.5	62.7	64.9
2006		74.6	69.8	68.4	63.0	72.0	65.5	71.5	66.4	68.7
2007		78.9	73.8	72.3	66.6	76.2	69.3	75.6	70.2	72.7
2008		83.7	78.3	76.8	70.7	80.8	73.5	80.2	74.5	77.1
2009		87.9	82.2	80.6	74.2	84.8	77.2	84.2	78.2	81.0
2010		92.3	86.3	84.6	78.0	89.1	81.0	88.4	82.2	85.0
2011		96.9	90.7	88.9	81.8	93.5	85.1	92.9	86.3	89.3
2012		101.8	95.2	93.3	85.9	98.2	89.4	97.5	90.6	93.8
2013		106.9	100.0	98.0	90.2	103.1	93.8	102.4	95.1	98.5
2014		112.2	105.0	102.9	94.7	108.3	98.5	107.5	99.9	103.4
2015		117.8	110.2	108.0	99.5	113.7	103.4	112.9	104.9	108.5
2016		123.7	115.7	113.4	104.5	119.4	108.6	118.5	110.1	114.0
2017		129.9	121.5	119.1	109.7	125.3	114.0	124.4	115.6	119.7
2018		136.4	127.6	125.0	115.2	131.6	119.7	130.7	121.4	125.7
2019		143.2	134.0	131.3	120.9	138.2	125.7	137.2	127.4	131.9
2020		150.4	140.6	137.9	127.0	145.1	132.0	144.1	133.8	138.5
2021		157.9	147.7	144.8	133.3	152.3	138.6	151.3	140.5	145.5
2022		165.8	155.1	152.0	140.0	160.0	145.5	158.8	147.5	152.7
2023		174.1	162.8	159.6	147.0	168.0	152.8	166.8	154.9	160.4

23-FEB-89